Instruments

THE MAGAZINE of MEASUREMENT and CONTROL

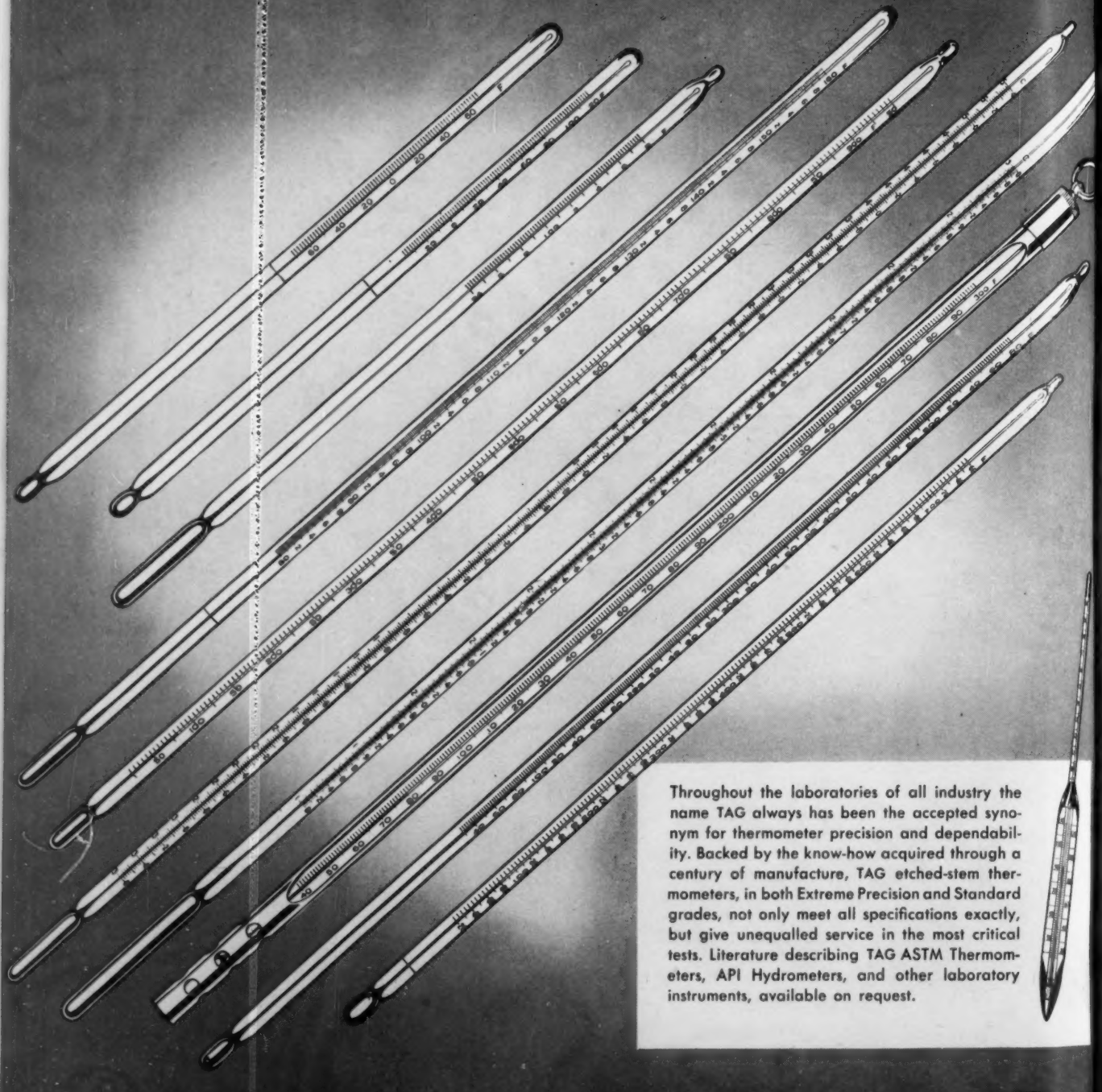
Vol. 21 JULY 1948 No. 7

Including the *JOURNAL* of the Instrument Society of America

TAG *Precision*

ETCHED-STEM

THERMOMETERS



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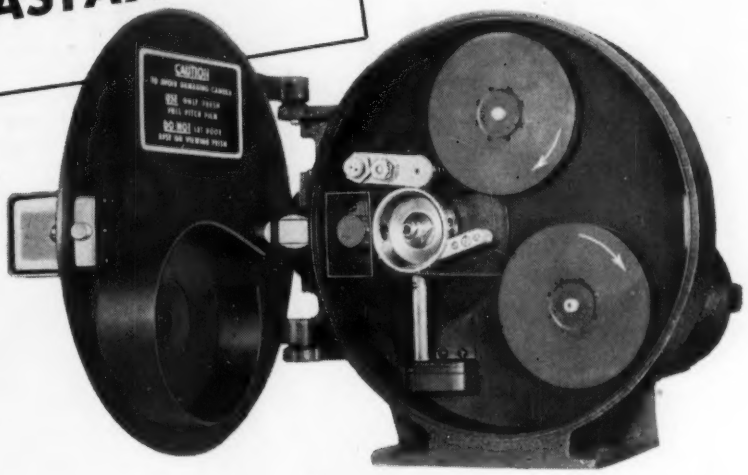

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An Improved MANOMETER CHECK VALVE

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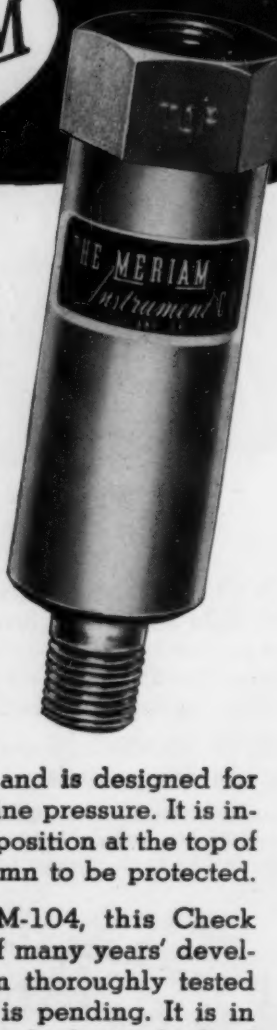

This unit more than repays its cost by preventing loss of indicating fluid and saving labor in re-servicing equipment. It also protects the manometer against high pressure surges.

Fabricated of stainless steel the Float Check Valve may be used with any Meriam indicating fluid. It is 4" high, 1-1/8" in diameter and is designed for 100 psi maximum line pressure. It is installed in a vertical position at the top of the manometer column to be protected.

Known as Model M-104, this Check Valve is the result of many years' development. It has been thoroughly tested and proven. Patent is pending. It is in keeping with Meriam high standards of accuracy and dependability and fills a definite need. May we send you complete information and prices?

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Instruments

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"Big Industry" Prizes Your Know-How

EVERY reader of these lines should plan to be in Philadelphia September 13 to 17. This third Conference and Exhibit of the ISA will be the largest—but its size is not the sole attraction. Another reason for going is that thousands of different devices, many of them new, will be displayed by 150 exhibitors. Still another reason is the rich variety of the program:

Four societies will participate.

Industrial Instruments and Regulators Division, A.S.M.E.—two sessions, five papers;

Subcommittee on Electronic Instruments, A.I.E.E.—two sessions, seven papers;

American Institute of Physics.—three sessions, nine papers;

ISA.—eight sessions, eighteen papers.

Also Educational Lectures on Electrical Measurements and Industrial Instruments.

But the strongest reason for going is that the atmosphere will be, as never before, one of Success. It is certain that many prominent industrial executives will attend and will be thinking of themselves as YOUR fellow-workers in the field of Instrumentation.

Signs pointing to this sort of a gathering have been unmistakable of late. In the following we shall attempt a multiple definition in terms of (1) the things, (2) the know-how and (3) the men—a multiple definition for high executives as well as for beginners.

In recent years readers have seen, more and more frequently, not only in all industrial journals but in newspapers and popular magazines, such expressions as "blast furnace instrumentation," "V-2 instrumentation," "cat-cracker instrumentation," "wind-tunnel instrumentation," "DC-6 instrumentation" and even "kitchen-range instrumentation."

In a material sense "instrumentation" means "gadgets." This is undeniable . . . but it is regrettable. Thoughful readers have intuitively felt, when they read or heard such an expression as "pilot-plant instrumentation," that even its purely physical, material meaning is not "a bunch of things," but a planned and orderly group of things.

Thus, the word "instrumentation" (with a small i) means more than instruments: it means a number of devices for measurement and automatic control intelligently and purposefully designed, specified and installed. It means AN ARRAY OF DIVERSIFIED MEASUREMENT AND CONTROL DEVICES WHOSE MANY SPECIAL FUNCTIONS ARE MARSHALLED INTO ONE COMMON MISSION.

Thoughtful readers may discern that even through this narrow physical definition — a definition of things — there shines forth the underlying idea of methodical coördination; that is to say, of a technique, a know-how, a science. A second point to be emphasized is that the word "Instrumentation" (with a capital I) was adopted in 1924 to denote the new science of measurement-and-control whose formulation then began.

Instrumentation has come to mean also a trend or "movement." It has a human meaning. A third point to be emphasized is that—

"All men, who conceive, invent, design, develop, build, sell, specify, apply, install, service and maintain measuring instruments, meters, gages, testers, counters, totalizers, automatic inspection devices, automatic controllers and all their related devices and accessories are brothers . . . making better things for more people, eliminating repetitive drudgery and making our world a better one."

The remark has often been made: "This sounds inspiring, but it implies that these people deal with many things

that I don't call instruments. Isn't there any limit to their field?" There is not. And the justification is that—

"The Machine Age has not been free from evils, but the Age of Instruments is making Technology a pure blessing."

Every occupational field has its hierarchy. The old pre-war aviation saying, "from grease-monkey to Aerodynamic Engineer" (now "to Test Pilot") has its echo in "from chart-boy to Instrument Engineer." Since, however, Instrumentation as a constituent of industry is even newer than instrumentation, the subtle gradation of job titles characterizing older phases of industry is still in its early evolutionary stage. The process may be likened to differentiation in biological evolution. Titles held by Instrument Men range from "mechanic" to "president."

The youngest apprentice nurse is proud of her calling because she plays a part in the honored field of Medicine. She knows far less than a newly-graduated M.D., but not even the most experienced physician has mastered all of medical science. So will it be with your know-how after the Philadelphia Conference—especially if you go there in person. Your own know-how may be humble, like that of an apprentice nurse, or outstanding, like a famous surgeons', but you can take pride in its being part of a great and good know-how—the distinct science of Instrumentation. This new science, like Medicine, is a specific compound of many different ingredients, among them:

1. A body of exact knowledge: an entirely quantitative science, like formal Physics.
2. A body of principles methodically formulated but not subject to mathematical presentation.
3. A precise terminology to express the new concepts and principles and permit the expression of other new principles when discovered in the future without having to amend the basics.
4. A technology, much like various other branches of engineering.
5. A set of guiding principles, somewhat like the combination of a purely material safety code and a code of moral precepts.
6. A loosely-organized and frequently-revisable body of facts and opinions, like Hygiene as compared to one of the exact medical sciences.
7. A set of non-mathematical descriptions of natural phenomena, like high-school physics and similarly designed for instruction at the apprentice level, etc., but distinctive in scope and purpose.
8. A body of operating directions, organization charts, equipment lists, training schedules, etc., not formulated into a science but preferably well organized (in various convenient ways by different compilers) for education, reference, etc.

Some of it is old; some new. The ratio of old to new, as in any other science, is indeterminable. The bald statement that "most of the factual subject-matter of Instrumentation is adapted from older sciences" was not false modesty fifteen years ago, but today it would unjustly slight the new generation whose many contributions, only recently declassified by military authorities and still clothed in the original equations, are enriching not only Instrumentation but the Queen of Sciences—Mathematics.

The proportion of old to new varies with each of the eight ingredients described above. Ingredients 1 and 7 are in large part Physics, whereas No. 2 is a body of new principles. No. 3 is necessarily new. No. 8 is always new, for it must be renewed every few years, but few persons care whether any part of it is truly scientific or technological innovation.

The eight ingredients are not distinct compartments. On the contrary, the formal divisions of Instrumentation—its "Parts"—planned simply for the convenience of readers — cover such obvious divisions of measurement and control fields as "Temperature," "Chemical Analysis," etc. Each formal division, however, contains all or most of the eight ingredients. There is also a growing number of informal divisions such as "Aviation," "Oil Refining," etc.

As with other bodies of useful knowledge, the whole is far greater than the sum of its parts.

Remember this: The whole is greater than the sum of its parts. It can be predicted that at Philadelphia in September, Instrumentation will come into its own. This prediction is a safe one, for it could be said that Instrumentation attained a lofty status in the highest circles of American industry a few weeks ago when a Wall Street leader accepted the ISA's invitation to be its 1948 banquet speaker. —MFB

The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 651

High-precision Automatic Direct-reading Barometer

New "Model 1050 Automatic Indicating Barometer" is a mercurial barometer provided with a photoelectric column-top follow-up which actuates a cyclometer register reading directly to thousandths of an inch and readable to fractions by interpolation. Entire instrument, except for amplifier cabinet, is enclosed in a thermostated housing maintained at constant temperature to eliminate completely all mercury-column and measuring-scale temperature errors. (Controlled temperature is above highest at location, so that no cooling is required in summer.) Use of precision-bore glass tubing for both column and reservoir gives perfect linearity and, hence, resumption of initial accuracy after replacement in event of breakage. Primary element of servomechanism which drives cyclometer register is a photoelectric detector employing a 0.002" ribbon of light passing through glass tube. Sensitiveness is so adjusted that only a fraction of this 0.002" width is used as the proportional band of the servomechanism. Thus, when desired, a 0.0001" change in mercury will initiate servo action. (Normally such sensitivity is not required, even at important weather stations or at airline altimeter-setting stations.) An important feature of new barometer is a built-in micrometer, used for initial set-up and also for periodical checking of servo. Initial set-up procedure applies compensations for temperature, gravity and capacity; after which these compensations are automatic. New barometer was a war development; was submitted to National Bureau of Standards, whose findings resulted in final improvements incorporated in the commercial "Model 1050." Servomotor now supplied is a brushless induction motor operating at only 100 rpm. and permitting system to reverse quickly and constantly without excessive wear.—*Ideal Laboratory Tool & Supply Co., 3619 Evans Ave., Cheyenne, Wyoming.*

Please mention number 701 when filling out card

Rechargeable Hearing-aid-type Instrument Battery

New re-chargeable hearing aid battery is a wet-cell A battery offering up to 18 hours of heavy service with one charge. It charges in six hours to full strength, using miniature charger plugged into regular a-c. outlet. Weighs 5 oz., is fully contained in a plastic case measuring 1¼" × ⅞" × 3¾".—*Hearing Aid Division, Miniature Batteries, Sycamore, Ill.*

Please mention number 702 when filling out card

Vacuum-tube Voltmeter

New "400C" tube voltmeter, said to be 30 times as sensitive as maker's "400A" voltmeter, provides readings from 0.1 millivolt to 300 volts, throughout a frequency range of 20 cycles to 2 Mc. Linear scale reads directly in rms. volts or in decibels based on 1 milliwatt into 600 ohms. Generous overlap makes possible more readings at mid-scale or maximum scale, where accuracy is highest. Special output terminal permits use as a wide-band stabilized amplifier, for increasing gain of oscilloscopes, recorders and measuring devices. Maximum gain is 54 db. In service as a voltmeter, new instrument may be used for direct hum or noise readings, to determine transmitter and receiver voltages, audio, carrier or supersonic voltages, power gain or network response. New voltmeter measures 8" × 7½" × 10" deep, and is operated from a 115-volt 50-60-cycle 45-watt power supply.—*Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif.*

Please mention number 703 when filling out card

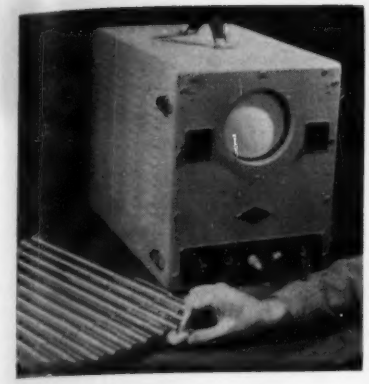
Vacuum-tube Voltmeter

New "Type 404A" vacuum-tube voltmeter is designed for a-c. measurements from 2 cps. to 20 kc., with useful range extending to 50 kc. Voltages from 0.001 volts to 300 volts can be measured readily. New portable battery instrument is said to have 10 times the sensitivity of a previous model. Input impedance is 10 megohms, shunted by a capacitance of approximately 20 μμfd. Accuracy is ±3% over a range of 2 cps. to 20 kc., ±7% from 20 kc. to 50 kc. of full scale including all error due to tube aging, warm-up, and battery voltage changes. Indicator is calibrated to read rms. value of a sine wave. Voltage scale is linear, and a db scale is also provided from —12 to +2. Each voltage scale is related to the next by exactly 10 db. Instrument measures 7½" × 10½" × 9" and weighs approx. 14 lbs. with batteries.—*Hewlett Packard Co., 395 Page Mill Road, Palo Alto, Calif.*

Please mention number 704 when filling out card

Ultrasonic-principle Flaw Detector

New "Type SRO5" is a smaller and otherwise new model of maker's "Supersonic Reflectoscope" (see *Instruments*, June 1946, page 359) for nondestructive testing of metals and other materials for internal defects, and for testing welds. Specifications match those of older model but radical



changes have been made in size, appearance and operation. By elimination of waste air space and re-design of circuits, weight and bulk have been decreased: "Type SRO5" is approx. 14″ × 16″ × 23″ and is carried by handles on case. Over-all weight is approx. 85 lbs., about half previous weight. Operation has been simplified by reducing number of external controls to five: sensitivity, pulse width, sweep length, screen markers, and frequency. Oscilloscope tube is a smaller (5″) high-intensity type. — *Sperry Products, Inc., 1505 Willow Ave., Hoboken, N. J.*

Please mention number 705 when filling out card

Square-wave Generator

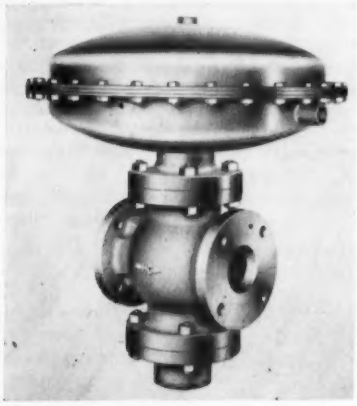
New "Type YGL-1" square-wave generator, for use in school and college research projects and in scientific laboratories, features six overlapping fre-

quency ranges, giving continuous coverage from 5 to 125,000 cycles. It delivers a rectangular wave output voltage with 25% negative pulse, and rise time for leading edge of 0.3 microsecond. Self-contained power supply provides stable output under conditions of commercial line voltage fluctuation. Output may be synchronized to external source if desired. Device is supplied in cabinet, but can be removed for mounting in standard 19″ relay rack. It weighs 44 lbs.—*Specialty Div., General Electric Co., Electronics Park, Syracuse, N. Y.*

Please mention number 706 when filling out card

Diaphragm-motor Valves

New "4000 Series Flo-Tested" pressure-loaded diaphragm control valves provide supersensitive regulation wherever controlled fluid may come in direct contact with diaphragm. Fluid pressure from outlet side of body is applied to under side of larger-area diaphragm instead of springs; loading pressure from a remote operator or air-operated instrument is applied to upper side of diaphragm in usual way. This construction eliminates both springs and packing box, thereby providing an almost frictionless valve, with no hysteresis. Maximum working pressure of valve is 250 lbs./in.^{2}. Common applications are back pressure and reducing service, as well as rate-of-flow control. When firing boilers or

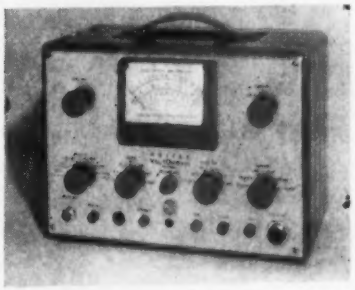


stills on natural gas, these valves prevent inlet pressure variations from disturbing controlled gas pressure. New valves use large-area diaphragm cases made from 3/16″ steel stampings. Large-area neoprene diaphragms with fabric insertion are used. A specially-designed seal eliminates gas leakage through the diaphragm. Available in sizes from ½″ to 12″.—*Hammel-Dahl Co., 243 Richmond St., Providence 3, R. I.*

Please mention number 707 when filling out card

Multiple-purpose Electrical Tester

New "Master VoltOhmyst" is claimed to feature circuit innovations providing for capacitance and current measurements over an extremely wide

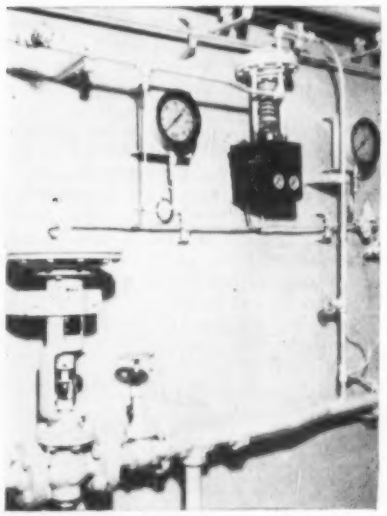


range. Capacitance measurements from 5 mmf. to 1000 mf. may be made with new instrument which also reads currents from 1 microampere to 10 amperes. "VoltOhmyst" is said to combine functions of capacitance meter, ammeter, audio voltmeter, a-c. voltmeter, d-c. voltmeter, ohmmeter, FM. discriminator balance indicator, and vhf. voltmeter. All scales necessary for all service readings are contained. New "VoltOhmyst" also measures oscillator strength, avc. voltages, bias-cell voltages, contact potential voltages, d-c. supply voltages, and a-c. supply voltages. Weighs only 15 lbs.—*Radio Corp. of America, Camden, N. J.*

Please mention number 708 when filling out card

Differential-pressure Control Pilots

New "Types DD-1" (direct-acting) and "DR-1" (reverse-acting) differential-pressure control pilots provide constant differential pressures for process work. Operating medium to control suitable diaphragm regulating valve, may be air, water, oil or gas. Available with three differential pressure ranges, ½-6, 2-20, and 15-75 lbs./in.^{2}. Maximum total static pressure for all types is 300 lbs./in.^{2} based on continuous operation and provided both pressures are maintained within differential range of pilot. When controlling differential between two pressures, higher pressure is applied to upper side of diaphragm of control pilot, and

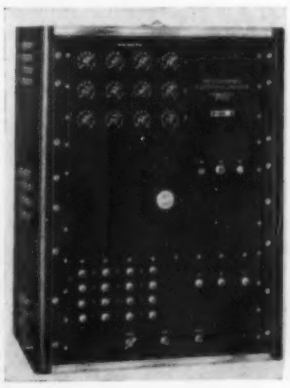


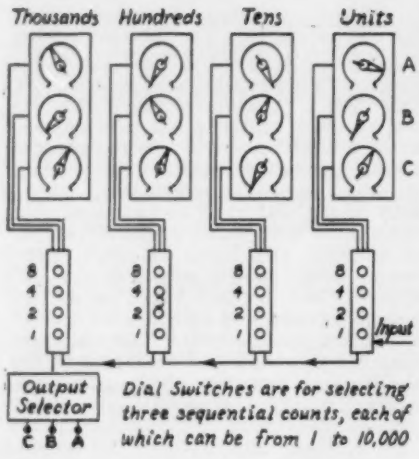
lower pressure to lower side. A simple turning of adjusting nut increases or decreases differential within adjustable range. One application (illustrated) is to provide clean sealing water for dredge mud pumps where casing pressures vary over wide range.—*Leslie Co., 225 Delafield Ave., Lyndhurst, N. J.*

Please mention number 709 when filling out card

Three-sequence Predetermined-count Controllers

New "Multiple Sequence Predetermined Electronic Counters" are an extension in principle of maker's single and dual predetermined counters, and can be supplied to predetermine any number of selected counts occurring in





sequence. At completion of each selected count a separate relay action is provided for each control function. Can be used to control any machine or process which now requires cams, gears, patterns, chain or other systems for timing control. New counters are designed for counting speeds up to 15,000 per minute and will predetermine three different counts that occur in sequence, each of which can be any number from 1 to 10,000. Output consists of three high-speed mercury-type relays, each energized at the completion of its associated count.—*Potter Instrument Co., Inc., 136 Roosevelt Ave., Flushing, N. Y.*

Please mention number 710 when filling out card

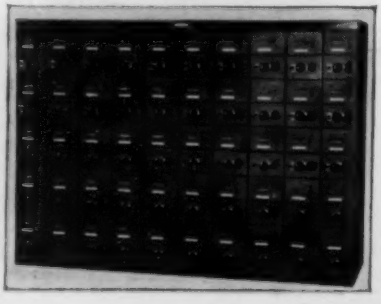
Attenuator-and-switch Units

New attenuators and switches feature an entirely different type of rotor, multiple wiping blades of which are made of special silver alloy and are enclosed in tamper-proof housing. Each blade conductor is individually spring loaded. Since rotor arms are considerably shorter than heretofore, lower over-all switch resistance is obtained, owing to extremely short conducting path. Another advantage claimed is that stray capacitance coupling between switch sections is decreased as a result of reduced length of rotor arm. With this type of switching arrangement, it is now possible to procure more circuits (poles) on one deck than previously.—*Daven Co., 191 Central Ave., Newark, N. J.*

Please mention number 711 when filling out card

Centralized Counting Systems

New centralized electrical counting systems are announced. Basic unit consists of electric counters grouped in a panel located in production control

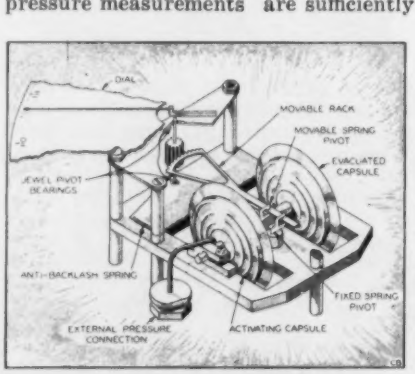


room. Counters are arranged to register output of various machines, operations or movements of parts, sub-assemblies, etc., throughout the plant. Illustration shows a centralized electric counter system used by a steel mill in controlling production of fifty remotely-located forming and fabricating machines. A toggle switch is used to turn on counter and pilot light when the machine is started. The plug-in receptacle is used to connect a tape-recording device when a permanent record is needed for analytical time studies. Countless variations of this system can be arranged to meet the specialized needs of each application.—*Production Instrument Co., 702 West Jackson Blvd., Chicago 6, Ill.*

Please mention number 712 when filling out card

High-precision Absolute Pressure Gage

New "Model 1001" absolute pressure gage is designed for use wherever pressure measurements are sufficiently

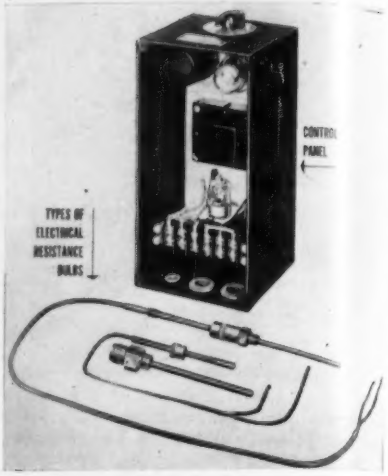


critical to warrant custom calibration. User selects range and units of measure such as millibars, mm. Hg, in. H_2O, etc. Primary measuring element consists of two capsules, one evacuated and the other connected to the measured medium. Capsules work against each other to produce movement of a connecting member. This movement is transmitted to pointer in conventional manner as shown in illustration. Each instrument is custom calibrated: each division of scale being individually graduated from increment to increment of pressure. Range, optional within limits of atmospheric pressure; sensitivity, 1 part in 1000; accuracy, 1 part in 500; graduations, optional; scale length, 15"; scale diameter, 6"; case dimensions, 8½" diam. × 3½" depth; weight, 5½ lbs.—*Airplane & Marine Instruments, Inc., Clearfield, Penna.*

Please mention number 713 when filling out card

Temperature Controller

New temperature controller, said to be simple, fast, and precise, uses a single electronic tube; has an electrical-resistance type bulb said to eliminate necessity of thermal compensation. New device is non-indicating, may be used to control temperatures to close tolerances in solids, gases or liquids. Units are available to cover range from —100°F. to 1200°F. and are adjustable within a range of several hundred degrees. Supply voltage may be 115 or 230 volts, 50-60 cycle a.c. Load capacity is 30 amperes at 115 volts, 20 amperes at 230 volts. Accu-

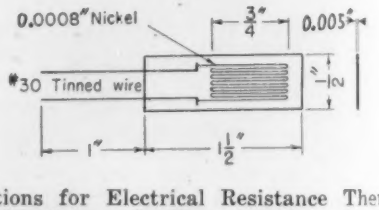


racy is independent of usual voltage variation. Normal response time is under three seconds. A 5" × 5" × 10" control panel, weighing less than 8 lbs. complete, is furnished and is provided with conduit knockouts and terminal board.—*Instrument Div., Thomas A. Edison, Inc., West Orange, N. J.*

Please mention number 714 when filling out card

Bonded-wire-form Resistance-thermometer Element

New "RdF Stikon" bonded-wire resistance thermometer element is said to be characterized by high stability, unusual accuracy, and extremely rapid response. Essentially it consists of a grid of fine nickel wire bonded into a paper-thin Bakelite wafer. "Type BN-1 Stikon" fits curve of resistance change versus temperature as defined by Army-Navy Aeronautical Specifica-

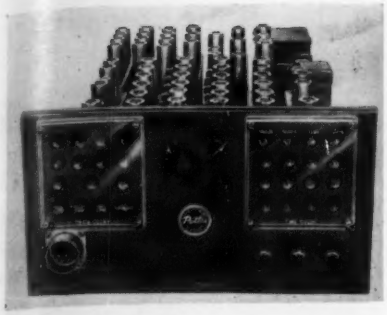


tions for Electrical Resistance Thermometers, and will operate into standard indicators, recorders, and controllers which are made to fit this curve. All "RdF Stikon" elements are well within tolerances permitted by these specifications. Exact deviation of each element from standard is given for 70°F. New elements operate with full accuracy in continuous service from —40°F. to +300°F.; give months of continuous service at 350°F.—*Ruge-de Forest, 76 Mass. Ave., Cambridge 39, Mass.*

Please mention number 715 when filling out card

Counting-method Frequency-measuring System

New "Frequency Chronograph" provides a simple means of measuring frequencies with accuracies of one part in ten million without need for calibrating, tuning, zero beating, interpolating or any of the other exacting procedures heretofore required. Method is said to be for Doppler frequency measurements and similar applications in which only a second or less time is



available for making measurements. Any frequency from 0 to 1.6 Mc. can be quickly and easily measured. Basic units of system are two high-speed electrical counters, a crystal oscillator and switch. These basic units can be used to count a predetermined sample of unknown frequency with absolute accuracy; simultaneously, cycles of a time-base frequency are counted in a second counter; unknown frequency is then found by dividing sample count by time interval. Cycles of the unknown frequency also can be counted during a predetermined time interval. Time interval is precisely established by simultaneously counting a selected number of cycles of a time-base frequency.—*Potter Instrument Co., Inc., 136-56 Roosevelt Ave., Flushing, N. Y.*

Please mention number 716 when filling out card

Sapphire Plug Gages

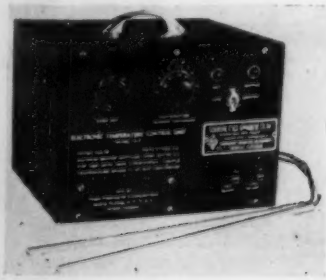
New large-size sapphire plug gages, up to 0.800", include new "Tipt-Type" sapphire gage—an instrument with approx. ¼" sapphire tip metallically

bonded to leading end of steel member. Maker's announcement states "Combined with a flexible handle, this tool will produce more gagings per day with less operator fatigue. It necessitates no wear tolerance, thus opening manufacturing tolerances." Sizes range from 0.020" to 1.000".—*Sapphire Products Division, Elgin National Watch Co., Aurora, Ill.*

Please mention number 717 when filling out card

Temperature Controller

New "Gyco-Phen Electronic Temperature Control" regulates power flow into electrically-heated devices to maintain any desired temperature within the range of 0-500°C. Its rated sensitivity is ±0.25°C., although in normal use such external factors as insulation, circulation, and rate of heat transfer may cause a deflection of one or two

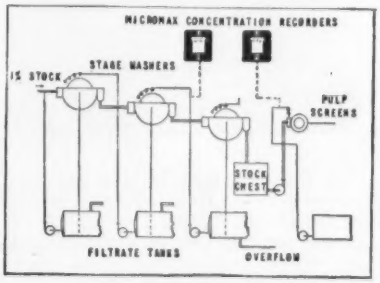


degrees from selected temperature. Employs an iron-constantan thermocouple which produces an electrical current variable with temperature changes. This current is amplified to actuate a 3 kwa. sealed-in-glass mercury relay. Relay remains closed until selected temperature is reached. Circuit is then broken until temperature begins to drop, and cycle is repeated. Dial for temperature control reads directly in degrees centigrade. May be used to control ovens, hot plates, water baths, "Gyco" and "Glas-Col" heating jackets, heated molds, and other similar heating devices. For refrigeration control a unit with normally-closed relay is also available.—*Scientific Glass Apparatus Co., Bloomfield, N. J.*

Please mention number 718 when filling out card

Soda-concentration Recorders

New "Micromax" direct-reading soda concentration recorders are designed to help kraft mills in checking pulp wash-

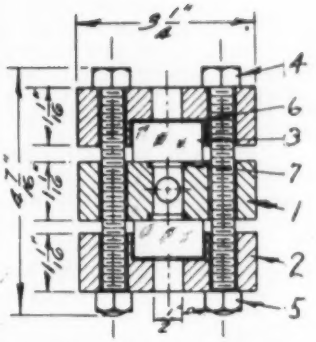


ing and soda recovery for maximum economy. Recorders continuously measure soda content remaining in wash water, are calibrated directly in lbs. Na_2O per gallon. They are applied to wash water lines from multi-stage washers, and to waste line to sewer. To determine total soda losses, new concentration recorder is supplemented with a "Micromax" liquid-level recorder, used in conjunction with a calibrated weir in overflow line. Pounds of soda lost per hour can be readily computed from readings of concentration and level recorders. New soda concentration recorders are said to be stable in calibration. They compensate automatically for variations in temperature of solution being tested; are easily installed by plant electricians or maintenance men.—*Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.*

Please mention number 719 when filling out card

High-pressure Liquid-level Sight-gage

New liquid level gage for use in laboratory and process work is designed for pressures of 10,000 lbs./in.^{2} or higher; has been tested up to 20,000 lbs./in.^{2}. It is said to have "greater strength than any other gage of its type" owing to its construction: chamber and covers are machined from bar steel stock, and the covers have a series of ½" ports through which liquid level, color or density is viewed. Glass is 11/16" thick tempered Pyrex, and O-Ring gaskets confine pressure on glass to a series of areas of ½" diameter circles. New gage is built in standard lengths up to approx. six



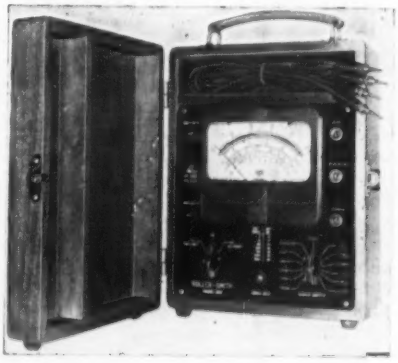
1. Chamber—bar steel; 4. Bolt—forged steel;
2. Cover—bar steel; 5. Nut—steel;
3. Glass—tempered; 6. Gasket—fibrous;
7. O-Ring—rubber.

feet. It is also available in stainless steel or other special metals to resist corrosive conditions. — *Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.*

Please mention number 720 when filling out card

Volt-ohm-milliammeter

New "Model 500" volt-ohm-milliammeter has wide selection of ranges: 0-3/15/150/300/750/1500/7500 volts a.c. and d.c. at 20,000 ohms per volt;

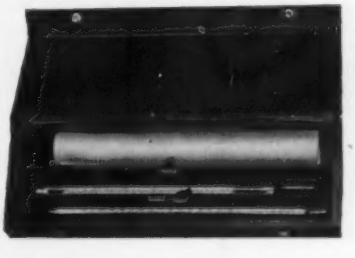


0.150 μa. /1.5 ma. /30 ma. /1.5 amp. /15 amps.; 0-5000/50,000/50,000,000 ohms and −10 to +73 db. Measurements as low as 10 microamperes, 0.2 volts and 1 ohm are easily read from long mirrored scale. Well-damped movement is said to prevent excessive slamming of pointer on overloads.—*Roller-Smith Co., 1766 N. Market St., Bethlehem, Penna.*

Please mention number 721 when filling out card

Thermometric Anemometer

New kata-thermometer outfit for measurement of air velocities in range between 10 and 600 fpm. consists of a "Princo" kata-thermometer, test thermometer and "Kata Reference Chart" from which air velocity is determined. The kata-thermometer is all-glass, with etched stem, about 10" long, with spirit-filled cylindrical bulb. Cooling action of



moving air upon sensitive bulb constitutes functional principle of instrument. Advantages of kata-thermometer method are claimed to be its accuracy at relatively low velocities; also, indication of velocity is independent of direction of air stream, even if direction is changing rapidly.—*Precision Thermometer & Instrument Co., 1475 Brandywine St., Philadelphia 30, Pa.*

Please mention number 722 when filling out card

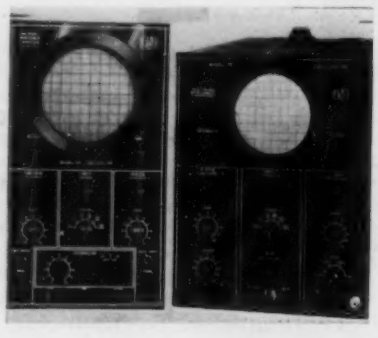
Pocket-size Sound-level Meter

New "Type 410-A" sound level meter is claimed to be the first light, pocket-size instrument of its type which covers the range from 34 to 140 db above standard ASA reference level. It includes all three standard ASA weighting characteristics to duplicate response of the ear at various levels, also a two-speed indicator, provision for using extension cable, optional types of microphones, vibration pick-ups, etc. Unit is 10½" long, 2½" diameter, and weighs slightly over 2 lbs. including batteries. — *Hermon Hosmer Scott, Inc., Dept. I, 385 Putnam Ave., Cambridge 39, Mass.*

Please mention number 723 when filling out card

C-r. Oscilloscopes

(1) New "Model 75" wide-range oscilloscope permits direct observation of composite video signal. Vertical amplifier response is ±2 db from 10



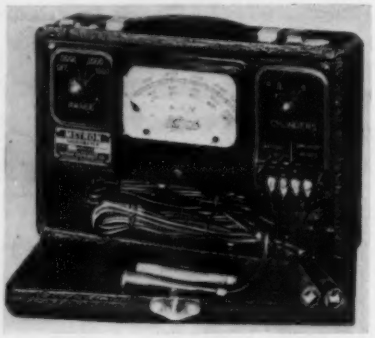
cycles to 5 Mc., permitting study of television signals and all wave-forms with high harmonic contents. Feature is self-contained voltage calibrator with accuracy of ±5%. Test probe has shielded cable to eliminate stray pick-up.

(2) New "Model 49-A" 5" oscilloscope has amplifiers compensated to give high-frequency sine and square-wave response, wide range linear sweep and is free from "hum" effects. Specifications include: Vertical sensitivity 0.02 volts r.m.s. per inch with attenuator switch in ON position, 0.5 volts r.m.s. per inch with switch in OFF position. Horizontal sensitivity 0.5 volts r.m.s. per inch. Input impedance—horizontal and vertical amplifier impedance, 0.5 megohm in parallel with approximately 20 mmfd. Input potential—maximum peak input potential on either horizontal or vertical circuits, 400 volts. Sweep—internal sweep adjustable from 10 cycles to 60 kc. Both horizontal and vertical amplifiers flat to within +2 db from 10 to 100,000 cycles.—*Electronic Development Lab., 2655 W. 19th St., Chicago 8, Ill.*

Please mention number 724 when filling out card

Automobile-distributor-type Tachometer

New "Type 48U" speed indicator for use in testing gasoline engines, requires no mechanical connection to motor: is easily applied by clipping



wires onto car battery and distributor breaker points. Readings are obtained from 100 to 5,000 r.p.m. A two-position switch provides direct crankshaft speed indications when used on either 6- or 8-cylinder engines. No internal batteries are employed since operating power is obtained from storage battery. Accuracy of 1% is claimed except under extreme ambient conditions. "No vacuum tubes or limited-life components are employed."—*Metron Instrument Co., 432 Lincoln St., Denver, Colo.*

Please mention number 725 when filling out card

Photoelectric Fluorometer

New photoelectric fluorometer is claimed to have wide range of sensitivity selection, 100 to 1,000 times greater than similar instruments. Flu-

orometer is for use with either micro or macro volumes of solutions and is capable of measuring concentrations of fluorescent substances as low as one part per billion in volumes as small as ½ cc. Particularly suitable for quantitative analysis of fluorescence of vitamins such as thiamin, riboflavin, etc.; quinine, atabrine, porphyrin and other fluorophors; metal complexes, oils, drugs, pharmaceuticals, etc.—*Farrand Optical Co., Inc., Bronx Blvd. and East 38th St., New York 66, N. Y.*

Please mention number 726 when filling out card

Volume-control Rheostat

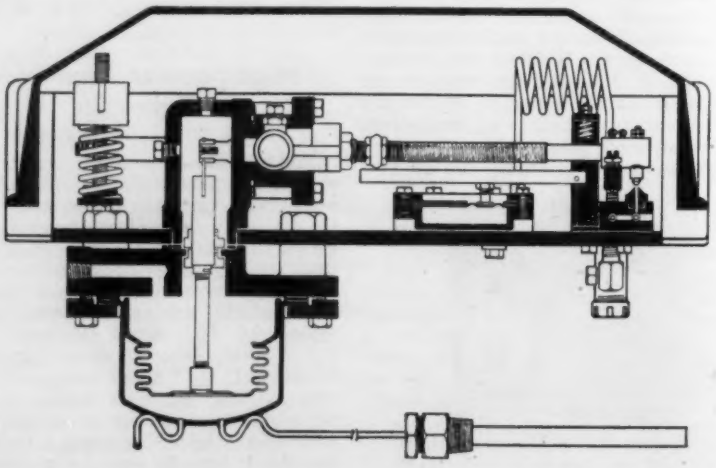
New 15/16" diameter carbon volume control is of entirely new design, having been developed from scratch to meet demand for more compact components. It is available with or without switch. However, the switch is factory-equipped or built integral with the control proper. Standard units have a 1" long knurled shaft, and are available in 250,000, 500,000, 1,000,000 and 2,000,000 ohm values, with the Z audio taper. (Other resistance values are available, as well as other shafts.)—*Clarostat Mfg. Co., 130 Clinton St., Brooklyn, N. Y.*

Please mention number 727 when filling out card

Differential Pressure Transmitter

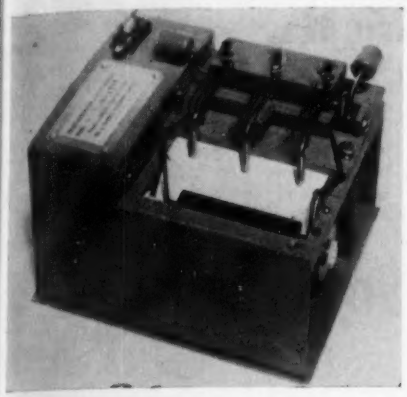
New model of maker's differential vapor-pressure transmitter permits easier installation and maintenance. Reference fluid is contained in bulb system similar to that employed in ordinary vapor-pressure thermometer. Bulb, fitted with standard 1¼" IPS bushing, is mounted in column and transmits reference fluid vapor pressure to measuring bellows through sealed tubing system. Primary function of transmitter, that of direct measurement of column product composition, has been retained, but instrument has been made considerably easier to install and maintain.—*Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill.*

Please mention number 728 when filling out card



Three-Component Ride Recorder for Shipments

New "Materials Handling Recorder" three-component accelerometer is small enough (7½" × 6½" × 6½") and light enough (less than 7 lbs.) to be concealed in merchandise. It has a 45-



day tape chart driven by a spring clockwork rewound by a dry battery and, being silent in operation, cannot be detected by freight handlers and loaders. It records all impacts in vertical, longitudinal and lateral directions and shows also when container has been turned over if this has occurred. Since each stylus moves against a known resistance, lengths of impact lines represent *G* units and may be calibrated in feet and inches of free falls for evidence more understandable by lawyers, claim agents, etc. Originally designed for manufacturers of bottles, etc., new recorder is claimed to be suitable for instrument users as well as instrument manufacturers.—*Analysis Sales Co., 1827 Union Commerce Bldg., Cleveland 14, Ohio.*

Please mention number 729 when filling out card

Freight-car Handling Recorder

New three-component accelerometer is similar to instrument described in preceding item but has different basic calibration and is designed for recording how freight cars are handled. It is placed inside a steel case which, in turn, is mounted in a specified way in the freight car. It records (1) mph. when car is humped to another; (2) vertical oscillations in *G* units; (3) lateral oscillations in *G* units.—*Analysis Sales Co., 1827 Union Commerce Bldg., Cleveland 14, Ohio.*

Please mention number 730 when filling out card

Terminal-installing Tool

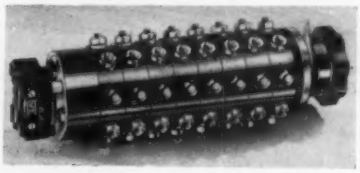
New "AMPli-Crimp" is for installing "Solistrand" terminals on solid or stranded wire in sizes 12 to 4 inclusive;

features interchangeable crimping inserts, compound leverage and full toggle action, heat-treated jaws.—*Aircraft-Marine Products, Inc., 1568 N. 4th St., Harrisburg, Pa.*

Please mention number 731 when filling out card

Rotary Tap Switch

New "Tesco Rotary Tap Switch" is said to have been developed for use in circuits whose requirements "cannot be fully met by existing types of

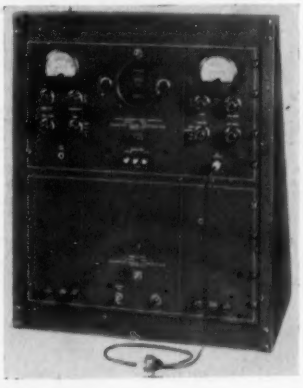


switches." Each switch section with 7 active positions and one off position is rated at 50 amp. continuous duty. As many as 12 switch sections in tandem handle maximum current of 600 amps. A current interrupter opens source of power when switch is rotated toward a new position, so that no arcing occurs. Circuit may be high-voltage, carrying an inductive load. Individual switch sections measure 2½" diameter over housing, 3¼" over terminal studs; length ¾".—*Eastern Specialty Co., Philadelphia 40, Pa.*

Please mention number 732 when filling out card

Signal Generator

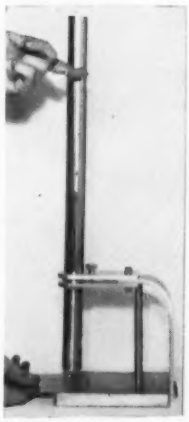
New "Type 211-A" signal generator is for testing and calibrating omnirange radio receiving equipment operating within frequency range of 88-140



Mc. It is also well suited as a precision-type amplitude-modulated r.f. signal source. Instrument consists of r.f. assembly, modulator-oscillator assembly, panel and indicator assembly, and external dual-regulated power supply unit. Calibration accuracy of frequency dial settings is ± 0.25%. Vernier frequency dial has 100 divisions and is coupled to the main tuning capacitor through a 120:1 gear drive. Each vernier division equals 10 kc. change in frequency and each vernier dial rotation is equivalent to a 1 Mc. change on main frequency dial. Crystal oscillator accuracy is said to be ±0.0035% at 110.100 Mc. and 114.900 Mc., operating temperature range 10° to 50°C. Modulation capabilities of 0-100% with internal oscillator or an external oscillator capable of supplying 2 volts across 100 K ohms. Instrument contains a demodulator or detector which supplies to front panel terminals a portion of the demodulated carrier. At 60% amplitude modulation, this voltage is 3.8 volts with a source impedance of 3600 ohms. Relay or cabinet mounting dimensions are 19½" wide × 12¼" high × 12" deep, and its weight with cabinet is 38 lbs. Electrical characteristics of instrument are input: 105-125 volts, 50-60 cycles, 160 watts and output: 575 volts d.c. @ 10-135 ma. avg. drain 55 ma.; 200 volts d.c. @ 0-65 ma. avg. drain 27 ma.; 7.2 volts a.c. @ 2.7 amperes.—*Boonton Radio Corp., Post Office Box 390, Boonton, N. J.*

Please mention number 733 when filling out card

Variable Impact Tester



New variable-impact tester enables determinations of impact resistance of various coatings. Conforms with method recommended by Steel Kitchen Cabinet Institute. Instrument has 2-lb. round-nosed impact weight which is dropped through tube to strike coated surface. Tube is graduated in inch-lbs. from 2 to 28. Weight is dropped from various levels, and sample is examined for flaking or cracking after each test. Instrument is adjustable to compensate for samples of different thicknesses.—*Henry A. Gardner Lab., 4723 Elm St., Bethesda 14, Md.*

Please mention number 734 when filling out card

Instrument-calibration-type D-c. Supply

New "Model 251 Regulated Low-Current Power Supply" is a lightweight unit for currents below 10 ma. at voltages up to 500 volts d.c. Output voltage is continuously variable from 0 to 500 volts, either positive or negative with respect to ground. Output voltage changes less than 0.5% at any setting, for line voltage variations from 95 to 135 volts. Output is stabilized by means of cascaded VR tubes, providing high degree of regulation. Variable output is obtained from tap of 25-watt GR precision rheostat. For finer voltage control, a 3-, 10-, or 15-turn voltage divider can be provided. New units are said to be useful in d-c. instrument calibration tests, meas-

urement of high resistances by volts-microamperes method, or in any low-current application where load is fixed but it is desired to stabilize power supply against line voltage variations. Features are said to be low cost, light weight, fine control, simple polarity reversal, no critical replacement parts, low power consumption, safety for personnel and for instruments under test. —*Beta Electronics Co., 1762 Third Ave., New York 29, N. Y.*

Please mention number 735 when filling out card

Multiple-purpose Electrical Tester

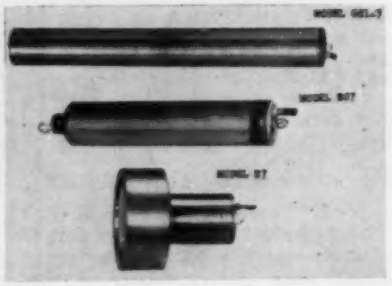
New "Model 450 Series" of "Hi-Meg Multitesters" incorporate a scale for making resistance measurements as high as 50 megohms to 1,000 megohms

without use of tubes or batteries. Low ohm ranges use a single-cell battery supplied with instrument. Available in 3 sensitivities — 1,000 — 5,000 — 20,000 ohms per volt. A-c. voltage measurements are claimed to be free from "usual frequency and temperature errors that exist with conventional multimeters." High degree of accuracy is said to be maintained by individually calibrating shunts and multipliers within 1%. Accuracy is 2%. Bench models are 8⅞" × 5½" × 3¾" and weigh 3 lbs. Portable models are 8⅞" × 7½" × 4¾" and weigh 4½ lbs.— *Radio City Products Co., 152 W. 25th St., New York 1, N. Y.*

Please mention number 736 when filling out card

Self-quenching Geiger-Mueller Counters

New series of specialized Geiger-Mueller counters includes (1) New "Model B7" bell type thin-window self-quenching counters for measuring softest beta and alpha radiations. Uniform mica windows in various thicknesses from 1 mg./cm.² are available in 15/16", 1¼", 1½" and 2" effective diameters. Makers claim high sensitivity, high efficiency, long life, stable precise operation and freedom from temperature limitations. (2) New "Model BC7" thin-wall all-metal beta ray counters for measuring more penetrating beta rays (200 kev. or higher), also suitable for use with x, gamma and cosmic radiations; utilize a standard collapsible aluminum tube for cathode shell; have total measurement including immersion in liquids at any temperature between —70° and 120°C.

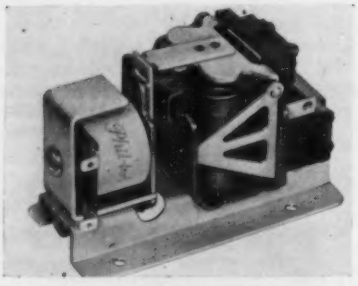


(3) New "Model GC1-7" all-metal cosmic-ray counters said to be "for the most exacting measurements of modern physics" embody "many marked improvements over any other counters in both physical construction and electrical characteristics." Spurious background almost totally eliminated by elimination of all insulating material from discharge region; cosmic-ray efficiency >99.5%; new gas filling exhibits unlimited life and counters filled with this mixture may be operated "for extended periods at very high overvoltages or in continuous-discharge condition with no detrimental effect."—*Nuclear Development Lab., P. O. Box 7601, Kansas City, Mo.*

Please mention number 737 when filling out card

Latch Relay

New "Phil-trol No. 22-27" latch relay consists of aircraft relay, armature of which is latched mechanically

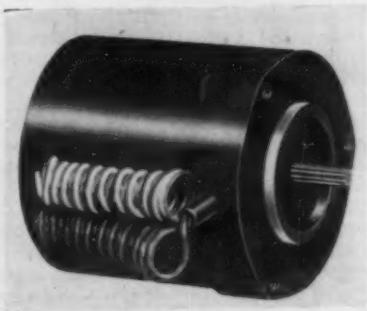


after coil is energized and trip coil which provides latch release. Supplied for voltages up to 230, from 1 to 5 pole, single or double-throw combinations. Contact capacity—10 to 20 amps. —*Phillips Control Corp., 612 N. Michigan Ave., Chicago 11, Ill.*

Please mention number 738 when filling out card

Instrument Motors

Two new types of maker's Miniature Drag Cup Motor can now be applied where motors had not generally been used. For example, they can serve as dynamometers for low-value torque measurement and in various control



mechanisms to obtain variable speed and torque through voltage control. Also, objectionable back-lash in a train of gears can be reduced. Special features of these units are light weight (7.6 oz.) and small size (1.922" length and 1.719" diam.); ability to reverse completely in as little as 0.1 second; fast starting and stopping characteristics; maximum torque at stall; and continuous operation under stall conditions without overheating. One new type runs at 3,000 r.p.m. and operates at 115 volts, 60 cycles; the other runs at 5,000 r.p.m. and operates at 115 volts, 400 cycles. In both cases maximum stall torques of 0.32 to 0.41 ounce-inches are produced.—*Kollsman Instrument Div., Square D Co., 80-08 45th Ave., Elmhurst, N. Y.*

Please mention number 739 when filling out card

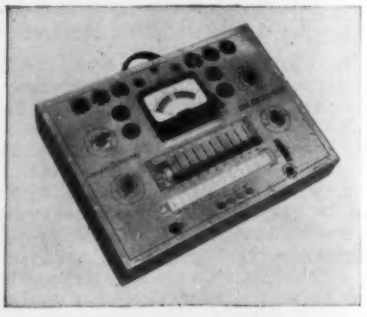
5-kw. Air-cooled and Water-cooled Triodes

New "492 and 492-R" high-frequency water-cooled and air-cooled triode amplifier and oscillator tubes have maximum rating of 5 kw. plate dissipation up to a frequency of 150 Mc. The "492-R" radiator is capable of dissipating full power with an air flow of 170 cfm., radiator design presenting optimum conditions for the ratings. The "492" anode is capable of dissipating full power with a water flow of 3-5 gpm. Water jacket is an integral part of tube, and a separate adaptor is provided for connection to external water lines.—*Amperex Electronic Corp., 79 Washington St., Brooklyn, N. Y.*

Please mention number 740 when filling out card

Electron-tube Tester

New "Type YTW-1" tube checker features flexibility: each tube element having its individual circuit switch.



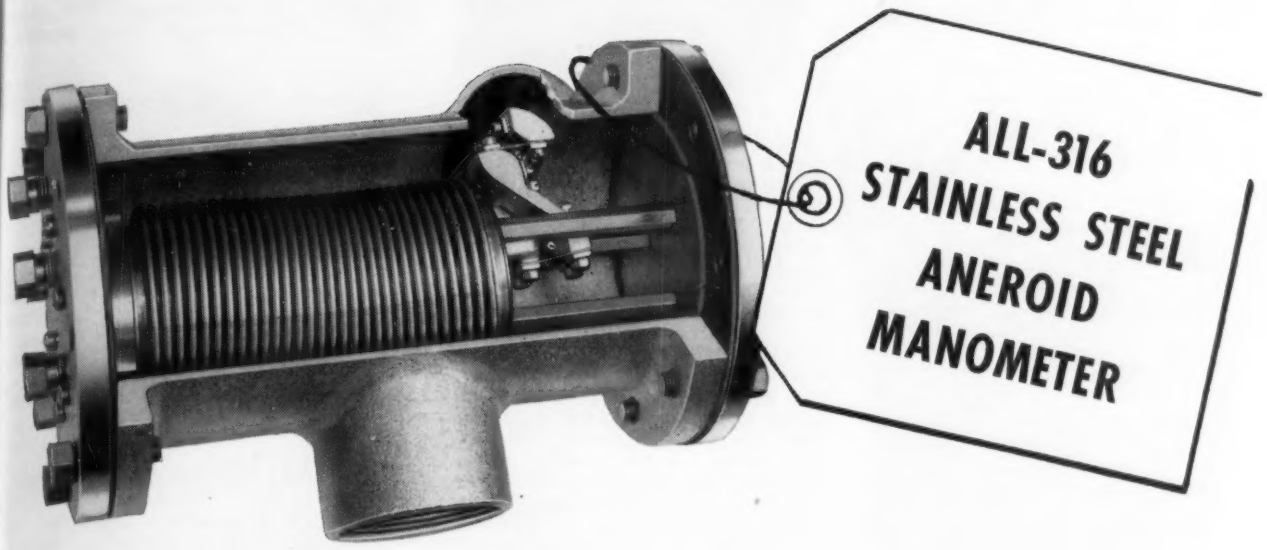
Device tests 4- to 8-pin standard, 5-pin small, 7- and 9-pin miniature, and lock-in tubes, as well as pilot bulbs and batteries. It tests for filament continuity, heater cathode, open elements, shorted elements, and quality of emission. Tester weighs 15 lbs.; operates from standard a-c. power source.— *Specialty Div., General Electric Co., Electronics Park, Syracuse, N. Y.*

Please mention number 741 when filling out card

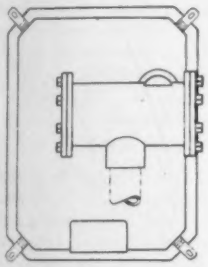
Sensitive (24-mw.) Relay

New "Type BK" relay is said to be suitable especially under conditions of limited power supply, also where precise operating characteristics are vital. Relay has molded Bakelite insulating parts, easily-accessible contact screws

Taylor-made for bad actors



For measuring flow, level and specific gravity of hard-to-handle corrosive materials



WORRIED about the problem of measuring tough corrosives? Taylor's new All-316 Stainless Steel Aneroid Manometer may well be the answer. We really mean *All*-316! Every single part from screws to housing is made of it. This gives the manometer a wider application range by combatting corrosion from such bad actors as:

nitric acid . . . acetic acid . . . sulphuric acid

phosphoric acid . . . caustics

similar hard-to-handle materials

Yet this Taylor Aneroid Manometer has all the advantages of the previous model which is still standard for ordinary jobs. It has been thoroughly field-tested in wartime chemical and petroleum plants where it earned a proud record for cutting maintenance cost to a minimum.

NO MERCURY TO REPLACE. No stuffing box. No internal pivots to wear out. Low volumetric displacement for full range differential. Differential pressure is measured by a bellows and transmitted through a torque tube. Here are a few money-saving advantages you get with the new All-316 Stainless Steel Aneroid Manometer:

NO SEALING FLUIDS OR BLOWBACK SYSTEMS NEEDED because corrosive fluids can be directly introduced into the manometer.

ENTIRE INSTRUMENT IS TOUGH and dependable for long service.

EASY TO CLEAN—no etched surfaces—no pockets.

RANGE CHANGES easily made by changing torque tube with another of a different range.

Available ranges, 20″, 50″, 100″, and 200″ of water differential. Working pressure, 300 psi. Ask your Taylor Field Engineer or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada. *Instruments for indicating, recording and controlling temperature, pressure, humidity flow and liquid level.*

Taylor Instruments
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capable of precise adjustment, and standard screw-type terminals. Supplied in one-pole or two-pole, normally-open or normally-closed arrangements, also double-throw. "Type BK" has d-c. coil rating up to 32 volts at 24 milliwatts. A-c. coil rating is 220 volts at 0.24 volt-amperes. D-c. contact rating is 1 ampere at 48 volts. A-c. contact rating 5 amperes at 110 volts, non-inductive. Dimensions: 2⅝" long, 2⅝" wide, 1 21/32" high.—*Allied Control Co., Inc., Dept. S, 2 East End Ave., New York 32, N. Y.*

Please mention number 742 when filling out card

Audio Oscillator

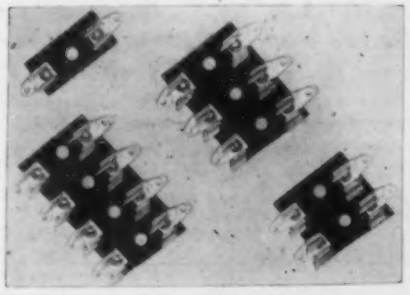
New "Type 204A" audio oscillator has frequency range of 2 cps. to 20 kc. in 4 decade ranges. Stability is stated to be better than ±3% throughout

frequency range. Announcement claims "There is no appreciable drift from warming or aging tubes, or aging batteries." Output is 5 volts into a 10,000-ohm load, and frequency response is flat within ±1 db between 2 cps. and 20 kc. Instrument requires no zero setting or other adjustment during operation. It is tunable directly or by a 6-to-1 vernier micro-drive control. Entire instrument is mounted in a welded dural case with splash-proof cover and measures 10½" × 10½" × 11". Weight with batteries, about 24 lbs.—*Hewlett Packard Co., 395 Page Mill Road, Palo Alto, Calif.*

Please mention number 743 when filling out card

Fuse Clips

New solidly based one-piece fuse clips with integral terminals are tinned for soldering. For 3 A G fuses, they are



available in 1-, 2-, 3- and 4-fuse banks from stock; other sizes to order. Clips are all in one piece.—*American Molded Products Co., 1652 N. Honore St., Chicago 22, Ill.*

Please mention number 744 when filling out card

Ultra-short-pulse Generator

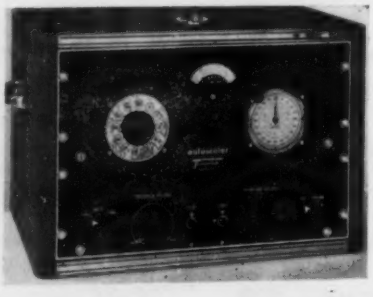
New "Mega-Pulser" ultra-short-pulse generator is believed by maker to be first commercially-available instrument of its kind. It provides a

pulse with spectrum which more than covers present video frequency range. Features are: Pulse width, 0.025, 0.05, 0.1, and 0.25 microseconds; pulse amplitude, 100 volts at 50-ohm impedance; pulse shape, flat-top pulses 0.05 microsecond and greater; pulse rise and pulse fall time less than 0.01 microsecond. Generator triggers from internally or externally provided pulse. Provides positive or negative pulse. Output pulse is delayed approximately 0.25 microseconds to allow observation on an oscilloscope. Useful for testing video amplifiers, cable testing by echo observation, testing radar systems, transient response study of electrical networks, etc. Operates on 117 volt, 60 cycles. Has self-contained power supply. Weighs 25 lbs.; measures 10" × 14" × 9".—*Kay Electric Co., Maple Ave., Pine Brook, N. J.*

Please mention number 745 when filling out card

Scaling Instrument for Radiation

New "SC-1A Autoscaler" is an improved model of maker's "Autoscaler" in electrical characteristics and in external appearance. Range of high-volt-



age supply has been extended to make it continuously variable from 500 to 2200 volts and is electronically regulated to 0.01% per percent change in line voltage. A time delay circuit has been added to control application of high voltage until all circuit tube filaments have come up to operating temperature. Minor design changes have been made to improve high-voltage stability and to provide a higher safety factor against flashover.—*Tracerlab, Inc., 55 Oliver St., Boston, Mass.*

Please mention number 746 when filling out card

Float Switches

New "LC-200" plug type float switch is for closed tank operation with pressures up to 100 lbs./in.^{2}. Sturdy 2-pole 2-hp. snap-action switch has drip-proof steel case, all-brass float (suitable up to 200° F.), and silicone lubrication. Ideally suited for pumps handling condensate return in a boiler system. New "LCF-200" is similar, but with flange mounting (5¾" bolt circle).—*Automatic Control Co., St. Paul 4, Minn.*

Please mention number 747 when filling out card

Geiger-counter-type Radiation Indicator

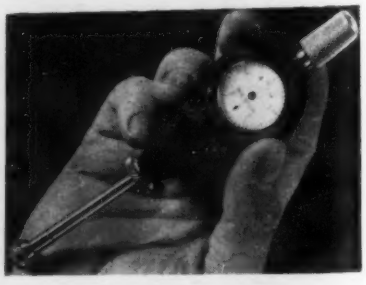
New "Model F-3" portable radiation detector is for detecting, and indicating relative intensities of beta, gamma,

cosmic and x-radiations. Light and convenient to carry, instrument is suited to uranium prospecting, health survey work, and locating misplaced radium. Low-range full-scale deflection indicates 0.5 mr/minute; high-range, 0.017 mr/minute. A counting-rate meter circuit affords means of making quantitative checks; amplifier operates earphones for aural monitoring. Geiger tube is housed in probe carried in compartment of case. Probe window may be opened for checking beta radiation. Indicator and control knobs are recessed to prevent possibility of mechanical damage.—*Technical Associates, 3730 San Fernando Road, Glendale 4, Calif.*

Please mention number 748 when filling out card

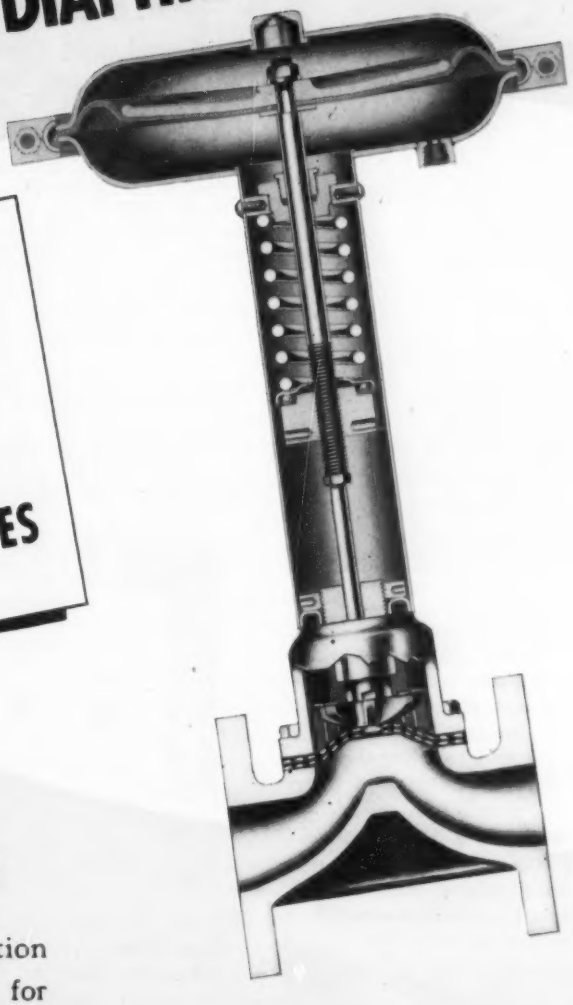
Dial Bore Gage

New "Nilco Dial Bore Gage" is a visible control inside-diameter indicator gage designed for rapid, convenient and accurate measurement of small internal diameters. Dial indicator quickly reflects size and condition of hole. Total weight about eight ounces. Has gradua-



tions in 0.0001" with a total travel of about 0.008". Three gages will cover a range of ⅜" to ⅞". In setting gage, head is inserted into master gage. Spring-tensioned range extension is released while in master as gage is tilted on slight angle. One twist of locking sleeve automatically locks range exten-

REVERSE-ACTION DIAPHRAGM MOTORS



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Kieley and Mueller Reverse-Action Diaphragm Motors were designed for use with Saunders-type chemical valves, needle port valves, and Milflo control valves where reverse-seated construction is impractical. The exclusive Neoprene "O" ring design provides a positive seal and eliminates stuffing box friction.

In the K&M Reverse-Action Diaphragm Motor there is no loss in effective diaphragm area, no loss in available stroke, no difference in spring rate. Direct or reverse acting — size and efficiency are identical.

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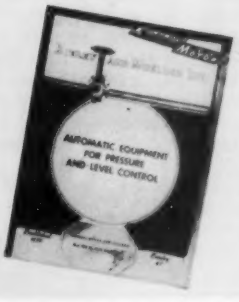

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NORTH BERGEN N.J.

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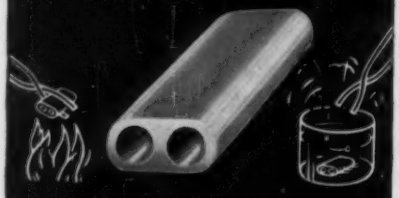
THERMOCOUPLE INSULATORS



This Gordon Thermocouple Insulator, heated red hot and plunged into cold water, came out just as good as new

Available only through GORDON, Serv-rite Thermocouple Insulators are made to stand the gaff of excessive thermal shock far above normal requirements.

For sturdy and reliable thermocouple insulator performance to meet peak production needs — Specify Serv-rite...a Gordon development backed by 32 years' experience in supplying industry with insulators that last longer and give better results.

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sion. When range is determined, fine adjustments to size on indicator are made with simple key arrangement which automatically seals gage so that gage cannot be tampered with.—*Nilsson Gage Co., Inc., P. O. Box 505, Poughkeepsie, N. Y.*

Please mention number 749 when filling out card

Ring-shaped Optical Flats

New optical flats are claimed by maker to be first of ring shape for checking ring seals in assembly and checking integral shoulder seals. These flats, with holes, are said to make it simple to check sealing ability of seals actually mounted on shafts, and of flat shoulders lapped integrally on shafts. Leaks can thus be detected before assembly, minimizing expensive rejections.—*Acme Scientific Co., 1450 West Randolph St., Chicago 7, Ill.*

Please mention number 750 when filling out card

Television Alignment Generator

New "Model 610 Television Generator" replaces TV sweep generator, trap-alignment generator and crystal calibrator. Operator can visually align TV

receivers to TV channels from 44 to 216 Mc., visually align IF stages of TV receiver, align all traps with calibrated signal and insert accurate marker at any point along IF response curve.—*Hickok Electrical Instrument Co., 10519 Dupont Avenue, Cleveland 8, Ohio.*

Please mention number 751 when filling out card

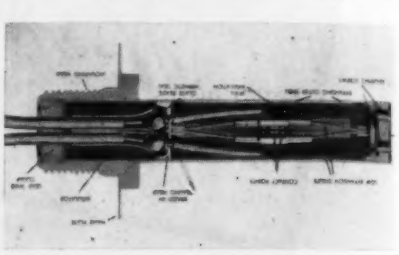
D-c. Timing Motors

New "Series 6300" low-current high-impedance timing motors are matched to receiving tubes. By operating over a period of time through enclosed gearing, they will integrate small instantaneous energy input from a receiving tube and "perform almost any desired amount of work," in contrast to a relay or solenoid whereby work is performed momentarily and therefore cannot exceed instantaneous energy input. Thus, new motors can operate heavier switchgear or other mechanisms. Time delay obtained is also a primary objective in many applications. D-c. motor with high-impedance winding requires less than 270 milliwatts power input, operates in plate circuit of a small receiving tube, permits translation of a minute electrical function into a large amount of work without use of thyratrons or other power equipment. Rotor winding has approx. 7000 ohms running impedance and draws only 6 milliamperes at 45 volts d.c. Permanent-magnet type motor has a totally-enclosed gear train. Speeds are 3200 rpm. down to 4 revolutions an hour. Motor is 2⅛" wide, 2½" high, 1⅜" deep; weighs 6 oz.—*A. W. Haydon Co., 111 W. Main St., Waterbury 32, Conn.*

Please mention number 752 when filling out card

Fire Detector

New "Detect-A-Fire" is stated to combine high-sensitivity, high-fidelity response to temperature setting, automatic repeatability plus ruggedness

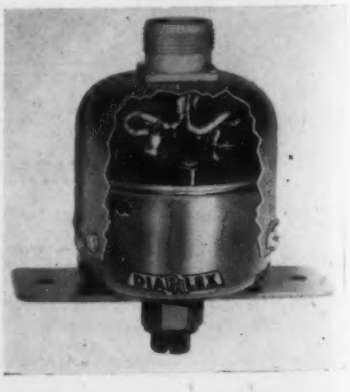


and long life. Unit is claimed to operate at almost the precise calibrated temperature, regardless of rate of temperature rise. Response is said to be inherently rapid since temperature-sensitive element is stainless steel casing. Expansion operates contacts. "Detect-A-Fire" units can be spaced at 25-foot intervals and 12½ feet from adjacent walls. Unit is hermetically sealed. Any temperature setting may be specified up to 725°F. and calibration is done at the factory. Electrical rating is 125 volts 5 amps a.c.; 125 volts ½ amp. d.c.—*Fenwal, Inc., Ashland, Mass.*

Please mention number 753 when filling out card

High-Pressure Switch

New "Hydtrol High-Pressure Switch" is said to provide true linear adjustment over exceptionally wide operating range from 50 to 5000 lbs./in.^{2}. On-off differential is adjustable and ranges

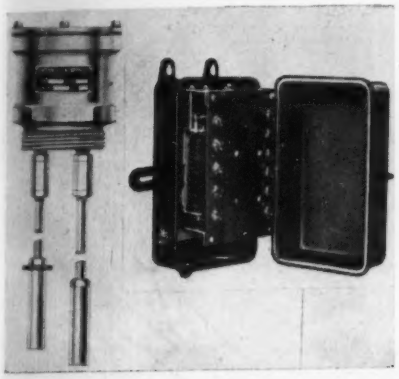


from 5 to 50%. Uses welded SAE 4130 steel diaphragm hydraulically formed and heat treated to withstand bursting pressure of 15,000 lbs./in.^{2}. New switch is especially applicable to high-pressure hydraulic systems containing inflammable liquids. Its uses range from heavy plastic molding and metal working presses to aircraft hydraulic systems. Especially useful where space is limited. Current rating 10 amps at 110 volts a.c., or 2 amps at 28 volts d.c.—*Diaphlex Div. of Cook Electric Co., Chicago 14, Ill.*

Please mention number 754 when filling out card

General-purpose Level Control

New "Type 10CB1" consists of an electric relay operating from a probe circuit through a transformer and a rectifier. Only stainless steel probe rods are located in liquid itself. It will control level of practically all electrically conductive liquids. Probe circuit may be set at several different sensitivities, will discriminate between a liquid and its foam, is not affected by saturated vapor above a liquid in a closed tank, permitting positive control of acid in



batch processing. Announcement states that "Type 10CB1 is the only floatless level control containing no vacuum tubes and operating with low voltage in the probe circuit." Supply: 115 or 230 volts, 50/60 cycles a.c.; power consumption ½ watt; output: s-p. d-t. relay; contacts designed for motor starter, motorized, or solenoid valve operation. Arc suppression is supplied on both contacts. Probe circuit will operate from a resistance as high as 3500 ohms.—*Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.*

Please mention number 755 when filling out card

Attenuators

New line of attenuators featuring decreased dimensions was designed for use in high-quality equipment where mounting space is limited and precision construction required. Same mechanical and electrical construction offered in maker's larger attenuators is supplied in new units.—*The Daven Co., 191 Central Ave., Newark 4, N. J.*

Please mention number 756 when filling out card

Lead Shield

New "Model 3030 Lead Shield" permits safe study of radioactive materials; consists of lead cylinder of 1¾" wall thickness, with center space which accomodates Geiger counters, ¾" diameter and 8½" long. New shield weighs

● The new HELICOID VACUUM GAGE gives the user several advantages at no extra cost.

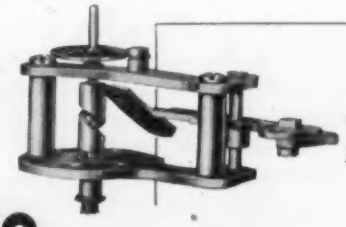
The pointer may be reset externally for changes in barometric pressure. This assures correct readings regardless of changes in room pressure.

The sub-divisions on the dial are in graduated steps of 0.2 inches. This makes the dial easy to read.

The dial graduations run counter-clockwise to denote negative pressure. This identifies the gage as a vacuum gage.

The special, phosphor bronze Bourdon tube has 300% greater torque. This assures more positive and precise response to slight changes in pressure, and results in accuracy to within 15/100ths of an inch.

HELICOID is first in new features — first in quality — first in durability — first in accuracy.



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FOR FLIGHT RESEARCH

Specially developed for recording in flight, the TYPE S12-A OSCILLOGRAPH and the TYPE OA-2 GALVANOMETER are ideal for operation under acceleration or vibration.

The TYPE S12-A OSCILLOGRAPH is a complete instrument with internal governor motor, gear-driven record, timing device, record numbering, automatic record-length control, and record footage indicator. Rigid cast aluminum case has carrying strap, measures only ten inches wide by 18 inches long, and weighs only 35 pounds.

Fully described in Technical Bulletin SP-167 B

The TYPE OA-2 GALVANOMETER can be supplied in 66 different combinations of sensitivity and natural frequency, for accurate recording up to 6000 cycles per second. The OA-2 is the only galvanometer suitable for use under extreme vibration or acceleration.

Fully described in Technical Bulletin SP-156 B

The TYPE MRC-12 STRAIN GAGE CONTROL UNIT is the smallest complete six-channel static-dynamic strain gage amplifier and balancing unit in existence. Complete with carrying strap, batteries, six amplifiers, six balancing boxes, and 2000-cycle oscillator, the MRC-12 weighs only 42 pounds.

Fully described in Technical Bulletin SP-177 B

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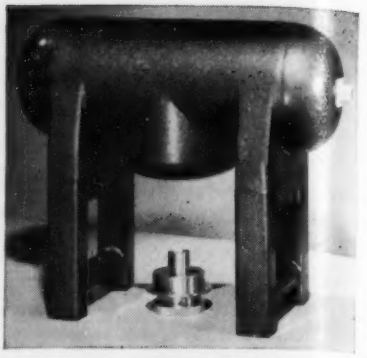


96 lbs. and has two handles. Shield comes complete with built-in sample holder which provides easily reproducible geometries, is easily dismantled for decontamination scrubbing.—*Instrument Development Laboratories, 229 West Erie St., Chicago 10, Ill.*

Please mention number 757 when filling out card

Cavity Frequency Meters

New "High-Q Tunable Cavities" are claimed to measure microwave frequencies to accuracies between 1/10,000 and

1/20,000. Can be used either as transmission or absorption cavities, providing continuous frequency coverage from 2575 to 3750 and 4500 to 10,500 Mc. Calibration is made against frequency standard accurate to one part in 100,000. Loaded Q's range from 5000 to 16,000. Tuning plungers use double wavetrap instead of sliding contact fingers. Model 28A is for 4500 to 5600 Mc. Model 208 for 5350 to 8100 Mc. Model 291A for 2570 to 3750 Mc. Model 901B for 8100 to 10,500 Mc.—*Industrial Dept., Sperry Gyroscope Co., Great Neck, N. Y.*

Please mention number 758 when filling out card

Variable Transformers

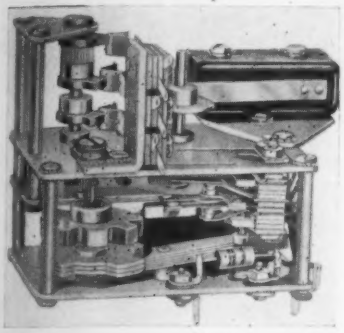
New "Adjust-A-Volt" portable metered autotransformers and isolation transformers provide control in 0.4-volt

steps with output voltage essentially independent of load. Operate on 50-60 cycles, require no lubrication and are available in autotransformer, metered autotransformer and metered isolation transformer models, for either 115- or 230-volt input. Output voltages in ranges 0-70, 0-140, 0-280 and 70-140 volts. — *Standard Electrical Products Co., Dayton 3, Ohio.*

Please mention number 759 when filling out card

Constant-speed D-c. Motor

New "Constant-Speed Direct-Current Motor" is claimed to be lighter, more compact, for use in weather balloons, airborne equipment, etc. Utilizes

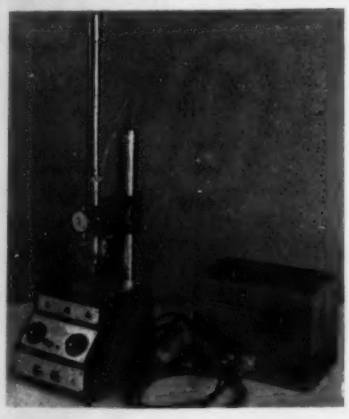


polarized magnetic drive principle of vibrating reed, said to provide "clock-like accuracy and synchronous operation previously possible only with a-c. equipment." Motor frame and reduction gearing occupies an area 2½" × 3½" × 1⅝". Weight, approx. 10 oz. Available for line or battery from 3 to 110 volts. Shaft speed 900 rpm.— *Amglo Corp., 4234 Lincoln Ave., Chicago 18, Ill.*

Please mention number 760 when filling out card

Instrument-shop Drill

New "Microdrill" for rapidly drilling accurate small holes, has a thermal motor feed and automatic control circuits. Danger of breaking even the smallest



drill and visual observation of the drilling operation are claimed to be eliminated. Vertical movement of drill is accomplished by controlling amount of electric power fed into a spring-loaded thermal unit. Drill is lowered to the work and held exactly at its surface automatically. Lamps indicate "at surface" and "at depth" positions of the drill. Drill has collet for 0.004" to 0.025" pivot drills and a maximum rec-

"Answer this question, Homer Sneet, And you'll be living on Easy Street!"

Emcee: "How much does it cost, by Air Express
To ship 10 pounds 1200 miles, no less?"

Homer: "Why didn't you ask me that *before?*
All it costs is $3.84!

"I use it many times each day—
It's the fastest possible way to make hay!
Easy Street's *already* my address,
Thanks to Scheduled Airline Air Express.

"What's more you get *door-to-door* service, too
—And all at *no extra cost* to you.
In these days of price inflation
Air Express rates are cause for elation!"

Specify Air Express-World's Fastest Shipping Service

- Low rates—special pick-up and delivery in principal U. S. towns and cities at no extra cost.
- Moves on all flights of all Scheduled Airlines.
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True case history: Truck and auto parts comprise big portion of Air Express shipments. Keep equipment rolling! Typical 36-lb. shipment picked up Detroit late afternoon, delivered Salt Lake City noon next day. 1507 miles, Air Express charge $16.58. Any distance similarly inexpensive. Phone local Air Express Division, Railway Express Agency, for fast shipping action.

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Rates include pick-up and delivery door to door in all principal towns and cities

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RELAYS *and* TIME SWITCHES
of Diamond AEMCo Quality

Open Type
"Can" Type
With Plug-in
Tube Base
A. C. or D. C.
Midget Relays
Dual Purpose
Relays
Delayed
"Make" or "Break"
Automatic
Circuit Control
"Current" and
"Potential" Relays

Ruggedly constructed to exacting specifications that are carefully engineered to provide ample safety factor . . . quality all the way through!

Automatic's relays are not built to a price but to an unexcelled standard of performance. That's why they are the choice of so many "big name" manufacturers.

We engineer and build a wide variety of stock model relays for practically all applications. A staff of competent engineers will design and build relays to fit *your* requirements.

Stock models or custom built, every relay we manufacture will deliver the same dependable performance that has made the "Diamond Seal" line the choice of those who measure *quality* by *performance*.

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This is the new flush mounting case for the well known Engelhard Direct Deflection Indicator-Recorder. It was shown for the first time at the recent Chemical Show in New York and received wide approval.

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ommended feed travel of 0.150". Maximum spindle speed, approx. 50,000 rpm.—*Teletronics Laboratory, 332 Maple Ave., Westbury, N. Y.*

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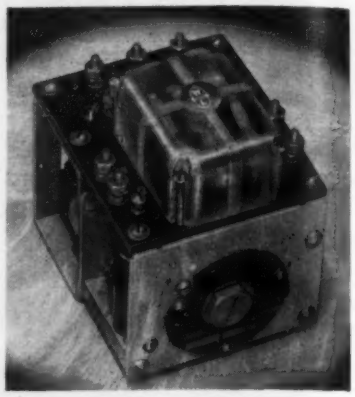
Time Delay Relay

New "Motor-driven Time Delay Relay" with composite connections is for use in processing, machine tool, signal, sound and other control equipments where adjustable time delay, after closing the pilot circuit, is required for remote, automatic or sequential operation. Two different timing sequences can be obtained—"delayed make" and "instantaneous make." Features include: composite connections, timing easily adjustable to 63 minutes maximum, immediate self-recycling, quick-make and break-load circuits.—*Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y.*



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Coaxial Barretter Mounts

New "Type-N" holders for sensitive barretter elements are for use with wattmeter bridges to measure absolute microwave power within ±5% accuracy. Cover four frequency bands between 2500 and 3300 Mc.; are fixed-tuned and matched to transmission line with a maximum VSWR of 1.50. Maximum average c-w. power measurable limited by barretter elements to 10 milliwatts. Range can be extended to 100 watts with directional coupler or attenuator. Four models: 2700 to 2900 Mc., 2500 to 2700 Mc., 2900 to 3100 Mc. and 3100 to 3300 Mc.—*Sperry Gyroscope Co., Great Neck, N. Y.*

Please mention number 763 when filling out card

Portable Potentiometer

New portable potentiometer for precise measurements of very low voltages, is designed for checking temperature-measurement instruments and for testing rotating machines, ovens, fur-

naces, oil-burners, etc. Potentiometer, in fabric-covered case, includes galvanometer, standard cell, working batteries and rheostats. Operates from 115-volt a.c. or from four No. 6 dry cells. Potentiometer has ranges, 0-60 and 0-6 millivolts. Voltage is read on two dials in 0.2-millivolt and 0.001-millivolt steps.—*Meter and Instrument Div., General Electric Co., Schenectady 5, N. Y.*

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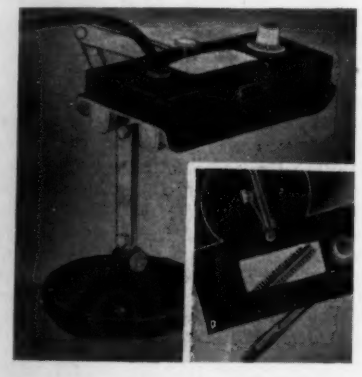
Illuminated Magnifier

New "Fluorescent Magnifier" provides illumination of 350 foot-candles on object from widely-divergent angles.



2× lens mounted in reflector between twin 5" fluorescent lamps. Fixture length 6¼", weight 10 oz. Four-watt lamps are rated at 2500 hours normal life.—*Stocker and Yale, 48 Birch St., Marblehead, Mass.*

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New "Megalyzer VHF Spectrum Analyzer" is claimed to meet requirement for radio spectrum analysis covering complete VHF range, for use by television stations for display of transmitter output frequency distribution, giving at a glance simultaneous side-band and carrier energies versus frequency. "Megalyzer" also useful as monitoring instrument for communication systems studies and analysis. Observes simulta-

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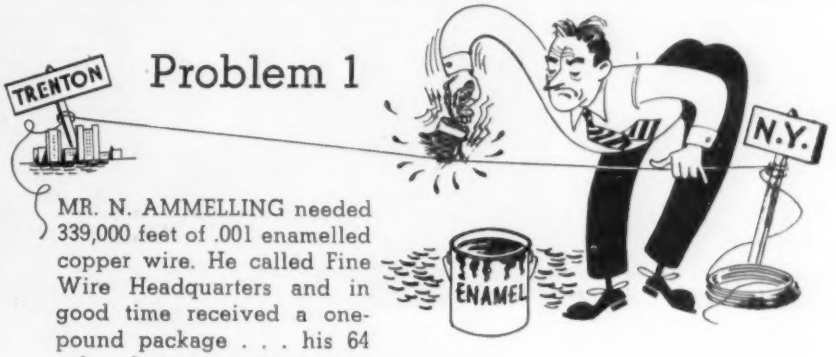

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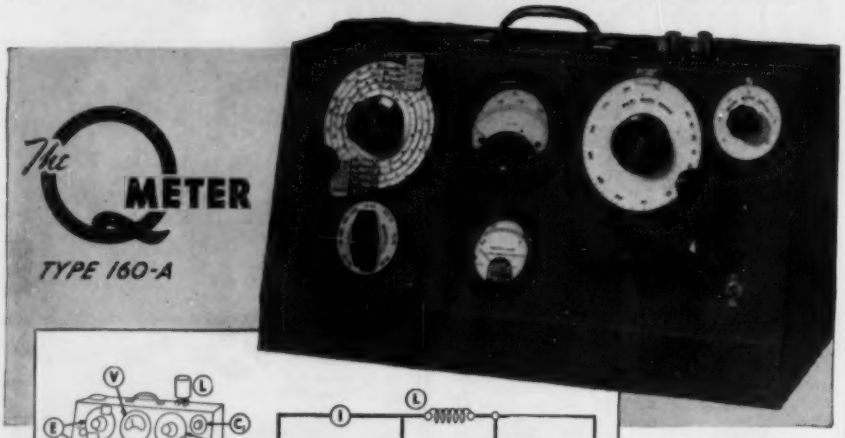

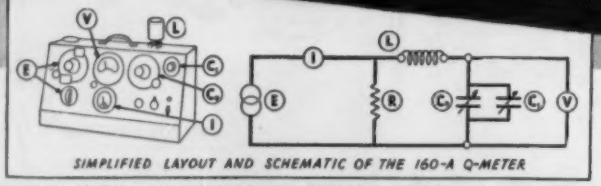

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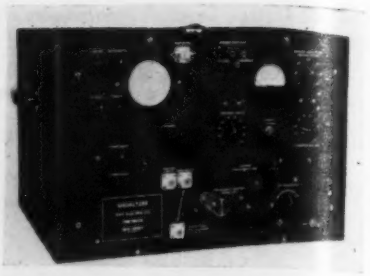

neously all signals within frequency sweep-band 30 Mc. wide within VHF range 30 to 300 Mc. Sensitivity of better than 200 microvolts is claimed. Analyzer has narrow frequency resolution of 100 kc. and may be used as sweep oscillator for conventional alignment work. Unit has self-contained power supply and operates from 117-volt, 60-cycle a.c.—*Kay Electric Co., Pine Brook, N. J.*

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Differential Pressure Gage

New "Kollsman Sensitive Differential Pressure Gage" combines high sensitivity and wide range where differ-

ential pressure measurements are required. Applicable to laboratory and flight testing of jet turbine engines. Instrument has wide differential range of 0 to 300″ of water, and working pressure range not exceeding 60 lbs./in.². Main pointer makes one revolution for every 10″ of water. Capable of measuring differential pressure as small as 0.1″ of water with pointer tip movement of 0.075″. Compensated for temperatures from −30°C. to +50°C.—*Kollsman Instrument Div. of Square D Co., 80-08 45th Ave., Elmhurst, N. Y.*

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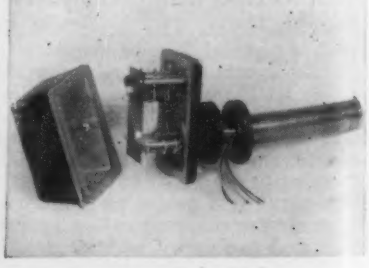
Thermal Load Relay

New "Type TRO" relay automatizes safe loading of power transformers to their full thermal capacity. Actuated by

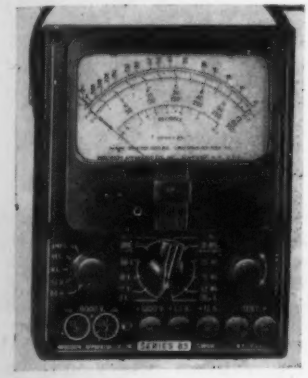


a bimetal mounted in a well in transformer wall in top oil zone, it continuously evaluates hottest-spot temperature of copper windings to operate three snap-action self-resetting switches. First switch operates with increase of transformer load to start cooling fans. If load increases and approaches the safe thermal operating limit, second switch closes to give a warning. If load continues to increase until thermal limit is reached, third switch either trips breaker or gives an alarm.—*Westinghouse Electric Corp., P. O. Box 868, Pittsburgh, Penna.*

Please mention number 768 when filling out card

Portable Test Set

New "Series 85 High Sensitivity Test Set" is for use in production, test, laboratory, school and service-maintenance phases of modern radio-electronics-communications, including AM, FM and television. It is said to incorporate features of much larger equipments, affording a sensitivity of 20,000 ohms per volt d.c. and 1,000 ohms per volt a.c.; 34 self-contained ranged are provided to 6,000 volts, 120 microamperes, 12 amperes, −70 db and 60 megohms. Microammeter is 4⅜" wide-angle with two-color scale-plate and easy-reading numerals. Case dimensions 5½" × 7⅛" × 3". Unit supplied complete with self-contained ohmmeter batteries and test leads.—*Precision Apparatus Co., Inc., 92-27 Horace Harding Blvd., Elmhurst, L. I., N. Y.*



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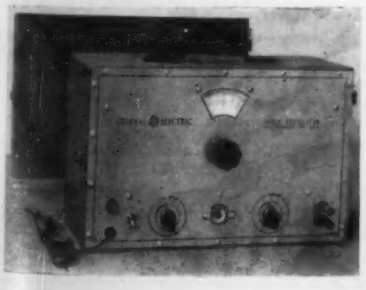
Audio Oscillator

New "Type YGA-4" beat-frequency audio oscillator, designed for use in testing radio receiver audio channels, PA systems, intercoms, etc., features a low-distortion output in one band over the audio spectrum from 25 to 16,000 cps. Large illuminated dial facilitates rapid checks of audio circuits and equipment for frequency response, dis-



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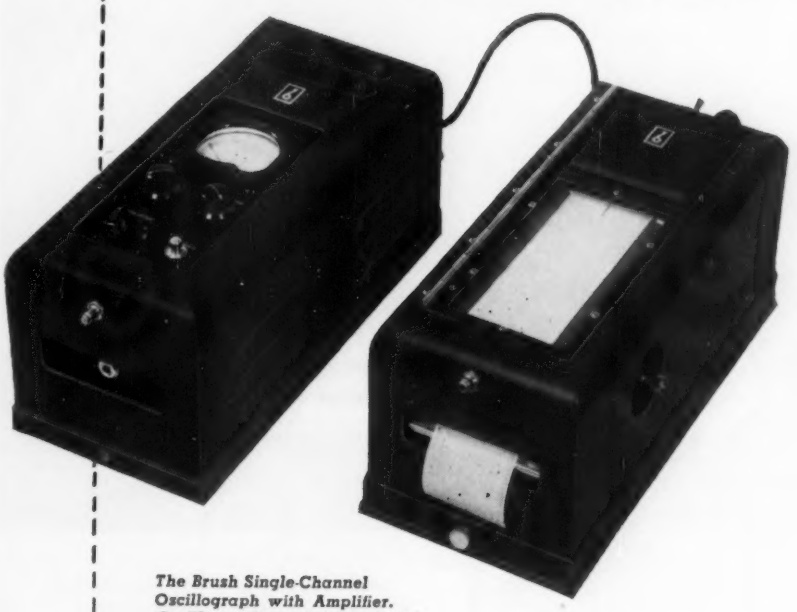

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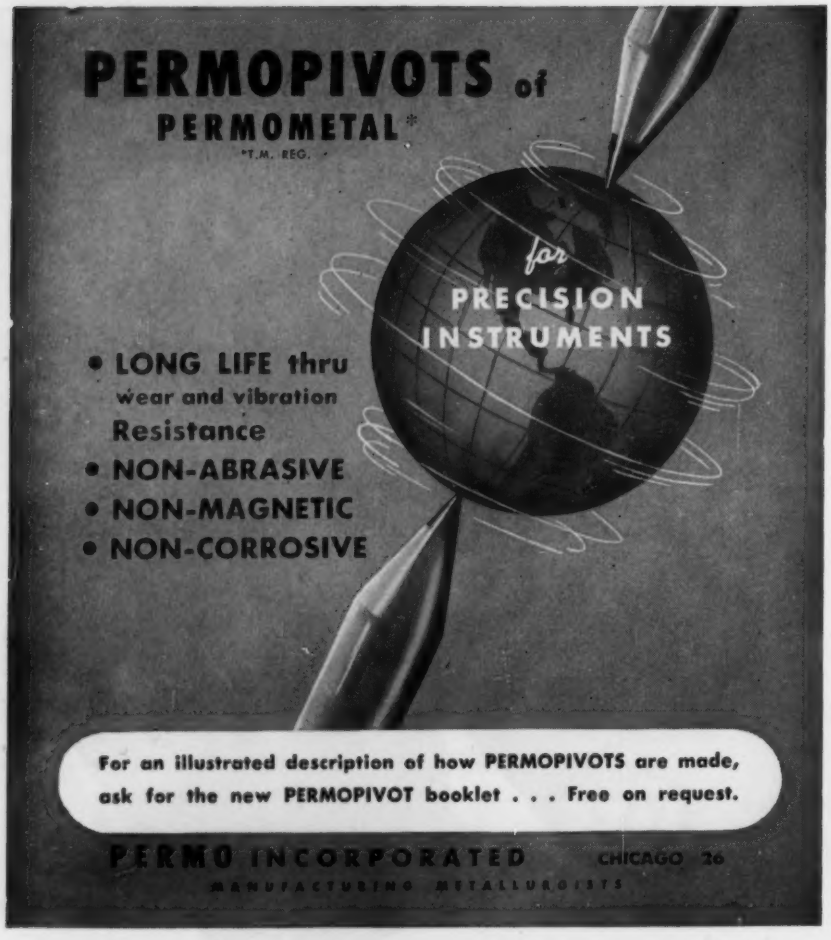

tortion, gain, power output and phase shift. Low-distortion output voltage remains constant within ±1 db over frequency range 50 to 15,000 cps. Instrument weighs 21 lbs.; operates on standard power of 50-60 cycles, 105-125 volts.—*Speciality Div., General Electric Co., Electronics Dep't, Syracuse, N. Y.*

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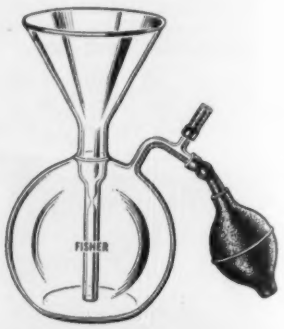
Glassware Washer

New desk-size "Harris-Mitchell Glassware Washer" for cleaning small laboratory glassware such as beakers,



flasks and graduates with corrosive acids, consists of a lower portion shaped like a Florence flask in which an upper portion shaped like a funnel is inserted. A side tubulature with rubber bulb permits user to force air into lower portion, creating a pressure which forces cleaning solution into funnel portion where glassware is held. A strong jet of chromic acid solution, for example, floods beaker interior which then is flushed with tap water and distilled water before use. — *Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.*

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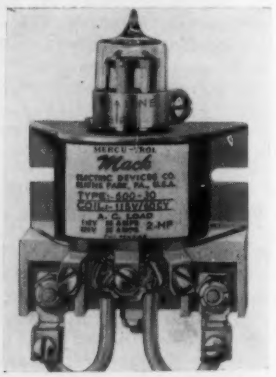
Mercury Relay

New "Mack Mercu-trol Relay with Built-in Sensitizer" features one moving part, hermetically-sealed tungsten



contacts, no exposed arc and silent operation. For use with contact-equipped instruments such as ammeters, galvanometers, thermostats, thermoregulators, etc. Both normally- open and normally-closed types incorporate mercury-to-mercury make-and-break contacts in inert gas. Motor loads up to 2 hp., current loads up to 35 amperes. Tube is interchangeable. — *Mack Electric Devices, Inc., 10 Glenside Ave., Wyncote, Pa.*

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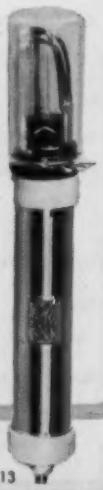

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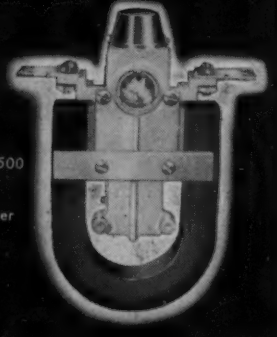

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- Sturdy
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Described in Bulletin 100

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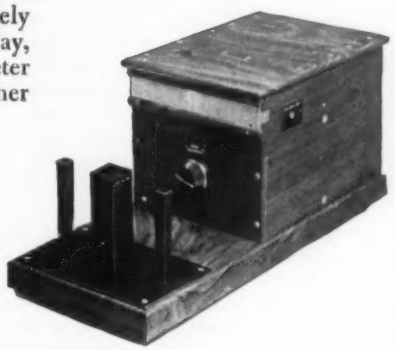

- Simple—for unskilled operators
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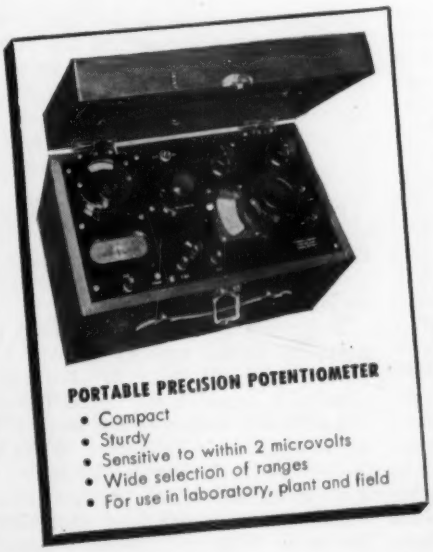

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3755 Ridge Avenue • Philadelphia 32, Pa.

A Flexible Electronic LOAD-CONTROL Method *for* MOTOR-DRIVE Operations

By G. C. WILSON, G. C. Wilson & Co., Chatham, N. J.

USE of vacuum-tube techniques in the control of plant processes and operations is steadily increasing by reason of such advantages as high sensitivity and virtually instantaneous response of the sensing element. To these advantages we believe should be added FLEXIBILITY.

Electronic control systems with sufficient flexibility to find broad use can be manufactured in such quantities as to utilize the economies inherent in mass production. The resulting lower cost permits a still broader use of automatic control equipment, with the usual benefits accruing from such use.

The ultimate result should be higher-quality products at lower cost for the consumer, resulting in a higher living standard.

The automatic control method described in this article illustrates the flexibility which the use of vacuum-tube techniques makes possible. This method was designed for use with electrically-driven pulverizing equipment. In the operation of such equipment, material is frequently supplied to the mill by means of feed screws. It is desirable to control the feed in such a manner as to avoid overfeeding the mill during those intervals in which the mill becomes overloaded or stalled. This overload condition may be of a temporary nature, which will clear if the feed to the mill is temporarily halted, or it may be of a permanent nature requiring the services of an operator to correct the difficulty.

In addition to the normal and obvious disadvantages associated with the stalling of a mill, it has been found that mill overloads may result in dust explosions owing to the excessive heat generated in the mill. This heat is generated by the great amount of frictional energy dissipated in the mill chamber, developed by the mill rotor hammers.

A list of the functions which the new control method performs will convey an idea of its flexibility:

(1) To shut off the feed screw motor after an overload persists on the hammer mill motor for a period of time adjustable from 1 to 9 seconds.

(2) To turn on the feed screw motor when overload condition on hammer mill clears.

(3) To turn off the hammer mill motor if overload has not cleared within a period of time adjustable from 20 to 30 seconds.

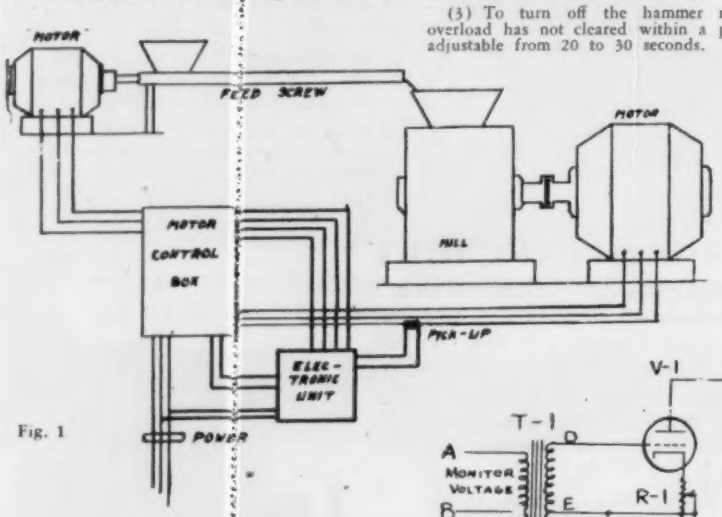

Fig. 1

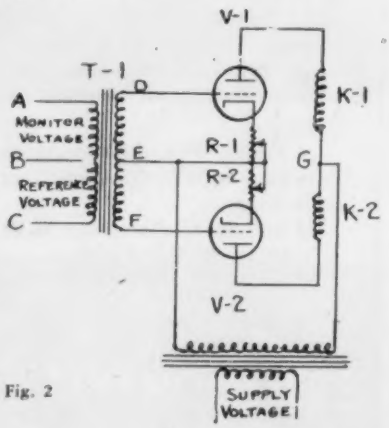

Fig. 2

Fig. 1 illustrates the wiring necessary to completely control the pulverizing process, the heavy lines being the additional wiring for the control system. The control system connects to existing controls in such a manner that manual controls remain operative for emergency use.

Perhaps the virtue of flexibility of electronic methods, which we mentioned earlier, can best be brought out by a brief description of this automatic control method.

Referring to Fig. 2, a voltage proportional to the current drawn by the pulverizer mill motor is obtained by placing a toroidal coil around one of the conductors serving the motor. This motor current is indicative of the load on the pulverizer mill. Therefore we have a voltage which we can monitor which indicates the load condition on the mill. This voltage is placed between terminals *A* and *B* of the primary winding of a transformer *T-1*. A reference voltage which is variable in amplitude is placed across terminals *B* and *C* of the same transformer. When the monitor and reference voltages are equal and 180 degrees out of phase, no voltage is generated on the secondary of the transformer. Since the reference voltage is adjustable the above condition can be achieved for any level of monitor voltage and therefore any load condition on the pulverizer mill. This gives extreme load flexibility.

Operation of the control occurs when the monitor voltage (representing the load) becomes greater or less than the reference voltage. In either case the unbalance causes a voltage to be generated between *D* and *F* in the secondary of *T-1*. This voltage will either be in phase with the reference voltage, or 180 degrees out of phase with it, depending on the direction of unbalance. This voltage is then imposed on the grids of vacuum tubes *V-1* and *V-2* which serve to amplify the voltage and determine whether it represents an underload or overload condition. This is accomplished as follows: An a-c. voltage is applied between *G* and *E* in phase with the reference voltage. This means that for half of each cycle, point *G* and therefore the plates of *V-1* and *V-2*, are positive with respect to point *E* and the cathodes of *V-1* and *V-2*. During this half-cycle, electrons are attracted by the plates and will flow to them if not prevented by the grids. For the other half cycle the plates will be negative with respect to the cathodes and the electrons having a negative charge are repelled by the plates and no current will flow regardless of the condition of the grids.

As we have shown, when the reference and monitor voltages are equal no voltage is generated in the transformer secondary from *D* to *F*. In this condition some electrons flow from *E* to *G* through tubes *V-1* and *V-2* for one half-cycle. This current is limited to a small value by causing the tube control grids to assume a voltage which is negative with respect to the cathodes. Electrons leaving the cathodes will then be prevented from traveling to the plate. This so-called negative grid bias is obtained, in a relative sense only, by making the cathodes positive with respect to the control grids, with variable resistors *R-1* and *R-2*.

Let us now assume an unbalance (due to an overload or underload) occurs. This will result in a voltage between *D* and *F*. If the phase of this voltage is such that *D* is positive with respect to *F* (and therefore *E*) when *G* is positive with respect to *E* then the bias on the control grid of *V-1* will be counteracted and more electrons will

flow in *V-1*. If the phase is reversed then *F* is positive when *G* is positive and more current flows in *V-2*.

Therefore we have a system where, for example, *V-1* responds to overloads and *V-2* responds to underloads. Flexibility here is obtained in the degree or percent of over or under load for operation by adjustment of *R-1* and *R-2*.

By placing suitable electromagnetic relays in the paths of current flow, immediate corrective actions can be taken or a waiting period can be initiated.

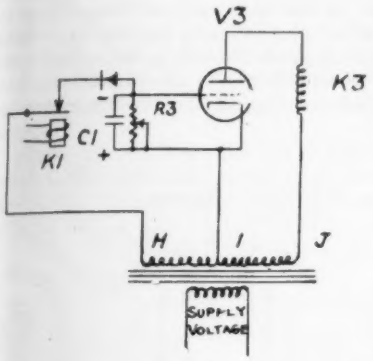

Fig. 3

For many processes such as this one, a short waiting period to allow for self-correction is desirable—and is provided. Reference to Fig. 3 shows this circuit. Relay *K-1*, which was shown in Fig. 2, is here shown to illustrate the interconnection between the load sensing circuit and the delay circuit. With normal load on the pulverizer, relay *K-1* is in the non-operate condition and the contacts are closed, permitting current to flow from *I* to *H* through the dry-disk rectifier during the half-cycle when *I* is positive with respect to *H*. During the next half-cycle, when *H* is positive with respect to *I*, current flow is greatly reduced by the high back resistance of the rectifier. Therefore a charge in the direction shown is accumulated by capacitor *C-1*, and by the control grid of tube *V-3*. This prevents flow of current through the tube.

When *K-1* operates, the circuit from *I* to *H* is opened and capacitor *C-1* begins to discharge through *R-3*. This results in the negative bias on *V-3* diminishing. After a length of time determined by the values of *C-1* and *R-3*, the control grid bias of *V-3* is reduced to a point allowing sufficient conduction in *V-3* for operation of *K-3*. This results in turning off of the feed screw. This time interval is made flexible by making *R-3* adjustable.

A similar circuit, also adjustable, turns off the pulverizer mill if the overload persists. Under this condition manual restarting is required. In this eventuality the control automatically resets itself and again takes charge.

It is noteworthy, we believe, that only two standard radio type vacuum tubes serve to accomplish all these functions.

Fig. 4 shows a practical embodiment of the new method we have described.

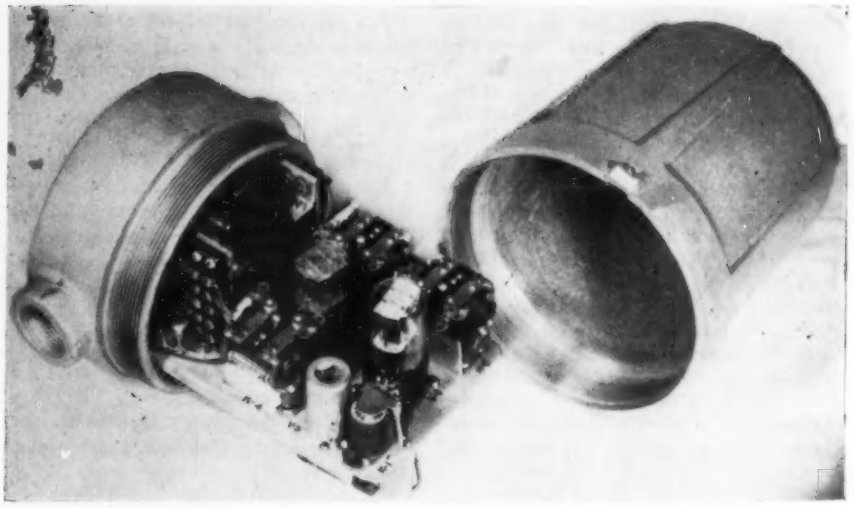

Fig. 4

Analyzing *the* INSTRUMENTATION *of a* CONTINUOUS CHEMICAL PROCESS

By ALLEN L. CHAPLIN, Consulting Chemical Engineer

Concluded from June issue

I. Signalling and Communication Instruments.

These instruments have important functions in continuous process operations. Alarms and signals are arranged in the central operating room to warn the operator, by annunciator flag, colored light or audible signal, of excessively high or low pressure, temperature, liquid level or other abnormal operating conditions. These instruments are the monitors of the process. They sniff air at various points and blow a shrieking siren if the room becomes untenable. They warn the boiler man when water is low or air has failed. If reactions approach hazardous temperature limits (e.g., nitration of glycerin) they sound an unmistakable area alarm and identify the unit by colored lights, thus giving operators a chance to escape while *safety controls* take over the task of arresting the reaction.

Processes which handle highly toxic materials must have annunciator type sampling analyzers not unlike CO analyzer installations developed for military aircraft.

When materials supply becomes low or a safety interlock has operated, the signalling instruments flash a warning to the operator. Processes which are operated on a time sequence program are controlled by a master sequence selector mechanism which also operates an appropriate signalling system to inform the operator of operating sequences. In general, a process is functioning properly when the alarm lights are green but attention is needed at some critical point when its corresponding red light is on.

The process illustrated in Fig. 2 uses many signalling instruments at the various strategic points. An annunciator identifies all points of the purge interlock system and informs the operator what caused it to "trip." If the gas velocity was too low, the appropriate flag drops and simultaneously sounds an alarm when the interlock system has operated. If the moisture content becomes too high, the annunciator flag drops and sounds an alarm but the interlock does not operate since this condition is not hazardous and requires only the operator's attention. Signal lights are associated with the annunci-

*Originally prepared for presentation before First National Instrument Conference, Instrument Society of America, Pittsburgh, Pa., Sept. 1946; presented in 1947 before Eastern New York, Metropolitan New York, and New Jersey Sections of the Instrument Society of America; partly re-written by author and reviewed by others; final revision made in April 1948.

ator and operate in a manner to flash a red lamp when the flag drops. The operator acknowledges recognition of the "trip" by pushing a switch at the annunciator station, which silences the siren and extinguishes the red lamp but lights an amber light which remains lit until any adjustments which the operator makes brings the variable back within operating limits. If conditions are not restored within a maximum time limit, the annunciator repeats its siren call and red light warning.

Other points of alarm are connected to the annunciator, such as failure of cooling water or excessive back pressures in the absorber or stripper, or over-pressures in the intermediate reactor. Instrument air pressure and other services are identified by annunciator flag.

A second annunciator is used to identify the source of gas leaks about some of the equipment. Products of the reactor are toxic and a multiple-point absorption type instrument is required to take, in rotation, air samples from strategic points of the process. As each sample of air is drawn through an analysis cell containing an absorption agent sensitive to the toxic materials, the heat of absorption causes a rise in temperature which actuates the annunciator flag to identify the area of the leak and sound an alarm.

Communications equipment is important in the modern chemical plant because operations are sometimes carried out at several different levels and coordination of effort is necessary during critical start-up or shut-down periods or during other emergency conditions. These instruments are of the conventional public-address or inter-office communications type and are sufficiently well understood to require no further description here.

J. Laboratory Check Standards.

Laboratory check standards instruments are necessary for the assay analysis of end products of processing units. The accuracy and sensitivity requirements of these instruments are of the highest order in production operations. They serve as guides and plant standards for standardizing and setting all production line instruments. They are operated by laboratory technicians or subtechnical help. Periodic test samples are taken to the laboratory for standardization on a schedule determined by experience.

Production instruments and controls are checked on the spot or in the shop with portable secondary standards which, in turn, are adjusted against laboratory primary standards at periodic intervals.

Laboratory check standards instruments are the primary reference basis for calibration of all process instrumentation.

Analyzing the Continuous Process for Application of Primary Operating Control Instruments.

The foregoing classification of process instruments offers a systematic basis for instrument application. The process control engineer is thus provided with a system of unit instrument operations comparable with the process engineer's unit process operations. His problem of instrumentation resolves itself into an orderly manner of thinking wherein he concentrates fully on one unit instrument operation until it is completely worked out, after which he passes to the next classification in order.

Material and energy balances are the first and most important instrument problem to consider and it requires the coördinated effort of the process engineer and the process control engineer to derive the best method of control. After the *primary operating controls* are applied, the next problem in chronological order is to consider the need for and application of primary measuring instruments; then safety controls; and so on in the order given in the condensed classification. The instrument engineer is a specialist in instrument mechanisms and he must make the decision on the proper equipment to do the job.

To best visualize the problem of control and operation of a continuous process it should be considered a distance-concentration system in which the concentration of reactants is a constant with respect to time at any given point in the system. Conversely, the batch process is considered as one in which the concentration at any point changes as a function of time. Instrumentation problems of the two processes are quite different. The continuous process has short-circuiting paths and recycle feedback loops which affect rate changes at various points in the system.

Analysis of the continuous process as a distance-concentration system offers

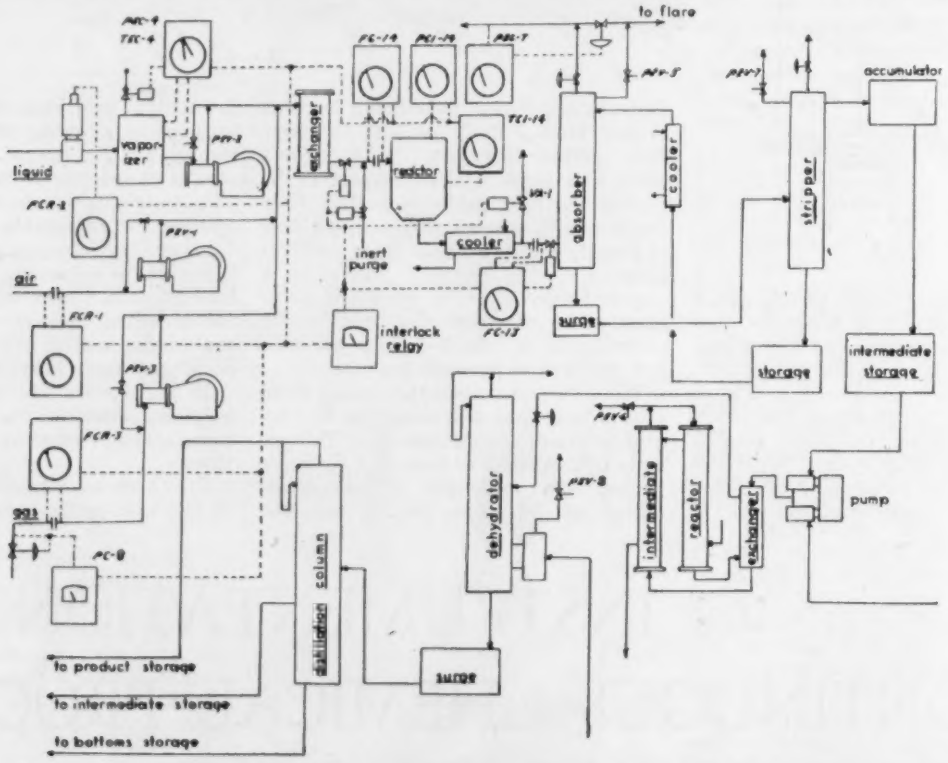

Fig. 2. Application of Safety Controls to typical continuous chemical process. (Repeated from June *Instruments* for convenience of readers.)

a base for design and application of the primary operating controls. The process material must be regarded as a forward-moving body whose concentration (relative basis) is constant at any point in the system but changes with forward displacement. This implies that a process divided into successive stages, with each stage regulated independently to maintain constant load on the following stages, will produce an over-all stable system. It follows, therefore, that a continuous process should theoretically be arranged for control by a sequence of primary operating controllers arranged in successive stages from the input end through to the discharge. Any load fluctuation on the input would work its way progressively through the system.

This is a good theoretical base but it is not sufficient to meet actual operating conditions. For example, load fluctuations do not occur always at the input end, and, furthermore, some provision must be made for diverting intermediate units from service for cleaning or regeneration. Recycle loops may cover only two or three intermediate stages, thus resulting in non-uniform load changes at certain points in the system. The theoretical base requires that rate changes be uniform throughout the system but this is only possible when the control time constants of all cascaded stages are equal — a rarity in actual practice.

Most continuous processes are made up of unit operations having varying time constants and the theoretical base is made practical and applicable by series interconnection of unit stages with surge capacity and averaging regulators. In some cases, processes have been designed and operated without surge capacity. Inventory has been kept small and special regulators used with provisions to dispose of interstage products in event of diversion of succeeding units.

A cascaded system must have provisions for diversion or equalizing loads of interconnected units. Furthermore, a continuous process cannot usually be regulated satisfactorily by application of automatic controllers at some intermediate point when the preceding stages are regulated by manual operation, especially when the preceding stages are subject to load variations. A regulator is unaffected by what happens in the process after it has done its job, but variations ahead are manifest as load and act to upset regulation. All stages do not have the same rate-change and those regulators bridged by recycle feedback loops must operate at faster rates than those operating on straight through feed; while those stages which are diverted from service have zero rate-change. In other words, the process can be likened to an electronic circuit which oscillates at a base frequency established by the input load and is frequency modulated throughout by the various recycle feedback loops. Intermediate rate-changes may vary but the input and output rates must coincide except for losses or make-up in the system.

Many processes have complex return loops and counter-current extraction phases which set up interactions and require interconnected controls to avoid long-time instability following a load change. This type of system usually has a critical unit or stage into which others react directly. Changes in this key unit affect directly the side loops and the controllers of these branch phases may be cascaded together to operate as a unit.

The important point in analyzing this type of system is to locate the key controller which affects directly the loading on other dependent branch units in the system. The master controller may then be cascaded with the dependent controllers by means of set-point reset or ratio-set control mechanisms to operate as an interlocked unit.

In Fig. 11, flow controller FCR-1 is the master load controller of the system shown. This controller is set to supply the demand on succeeding stages of the process through line "A." Changes in this demand reflect as load changes on controller FCR-1 and it must reset controllers FCR-2, FCR-3 and FCR-4 to meet the changing demand. The use of cascaded control systems obviates, in many cases, the necessity for interstage surge but performs most satisfactorily when the time constants of the "bridged" units are equal. The greatest benefit derives from the application of cascaded controls to branch units of a process which cannot be operated independently of the main load line because of delay in reaching equilibrium following a demand change.

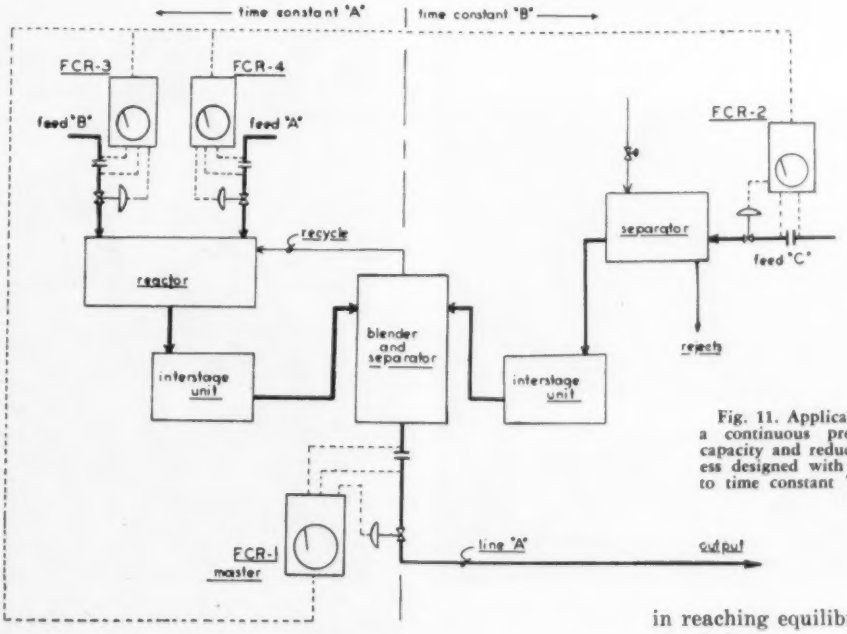

Fig. 11. Application of Cascade Control to a continuous process to eliminate surge capacity and reduce process inventory. Process designed with time constant "A" equal to time constant "B".

Conclusion

This analysis is not intended as an over-simplification of the many ramifications of control applications. It is presented as a foundation and guide to the proper instrumentation of a chemical process based on the foregoing instrument classification.

To the uninitiated, a continuous process is quite mystifying with respect to regulation and control. Furthermore, instrumentation applied without a basic plan is likely to be inadequate or overdone. The writer has applied the *use function* concept of process analysis and it is his belief that it establishes a unified plan of approach which is applicable to both straight-through and recycle processes.

Acknowledgement. The author acknowledges his indebtedness to Messrs. J. G. Kerley and R. H. Tubman of The Shell Oil Co. for contributions in the preparation of this article.

Operation *and* Care *of* Circular-scale Instruments

By JAMES SPENCER, Meter Division, Westinghouse Electric Corp., Newark, N. J.

GOOD instrumentation is a matter of mutual interest between the manufacturers and the users of electrical instruments.

In accepting this fact, it can readily be appreciated that the economics of instrumentation is dependent on the users having sufficient information to properly handle, maintain and service their instruments.

In the past few years we have seen the circular-scale instrument presented and accepted to the extent of hundreds of thousands. Owing to this increasing use of these instruments, it is felt that information beyond that given in manufacturers' instruction data should be helpful to users. No matter how well an instrument is designed and built, it will fail in its purpose if it is not given the proper attention— hence the following series is presented.

PART I.
D-C. CIRCULAR-SCALE INSTRUMENTS
PERMANENT-MAGNET MOVING-COIL TYPE

In order to repair a defective instrument efficiently, it is necessary for the maintenance man to know the construction details to avoid further damage. (See Figs. 1-8 incl.) To obtain this information, it is well to outline the details of dismantling the instrument, the reverse of which is the procedure for reassembling it.

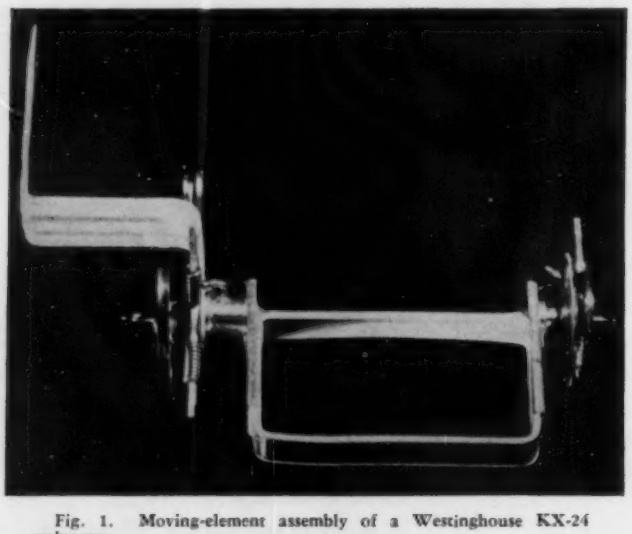

Fig. 1. Moving-element assembly of a Westinghouse KX-24 voltmeter.

As with all types of instruments the majority of operations, such as the removal of screws and nuts, disconnecting leads, removal of instrument from case, etc., are all obvious operations. There are a few operations of dismantling and reassembling of the KX-24 and DB-12 instruments however, that warrant some explanation and description. These we shall emphasize as we outline the dismantling operations of these instruments.

KX-24 Instrument

Assume that the instrument defect is an open coil. While this would seem to be a major repair—as it is in most instruments—it is not difficult in the circular-scale type.

The first step in making this repair is to remove the cover by removing the four front screws and lifting it. The case can be removed from the instrument, leaving it accessible for repairs by removing the nuts, lock washers and triangular bar washers from the back of the instrument.

Next, unsolder the ground lead connected from one terminal to the top plate of the element and the swamping resistor connection at the lower spring holder.

The scale plate consists of two pieces: the scale and number plate, and the title plate or mask. A slot in the back of the scale plate slides over a shouldered hex nut positioning the plate. The mask is then placed over the lower part of the plate and the complete assembly is held tight by two screws. To remove the scale plate, slide the plate back off the shouldered nut and *carefully slide the plate over the pointer.*

Three screws hold the element to the magnet assembly. These screws are accessible through holes in the element top-plate. When these screws are removed, the pointer should be rotated to the extreme left position of travel. This lines up the coil with the open section of the inner pole piece and allows for removal of the element. It is not necessary to place a keeper across the magnet poles when the element is removed. Raise the element straight up out of the magnet. *Extreme care should be exercised during this operation* as attempts to remove the element with the coil in any other position may cause further damage by jamming the coil against the pole piece.

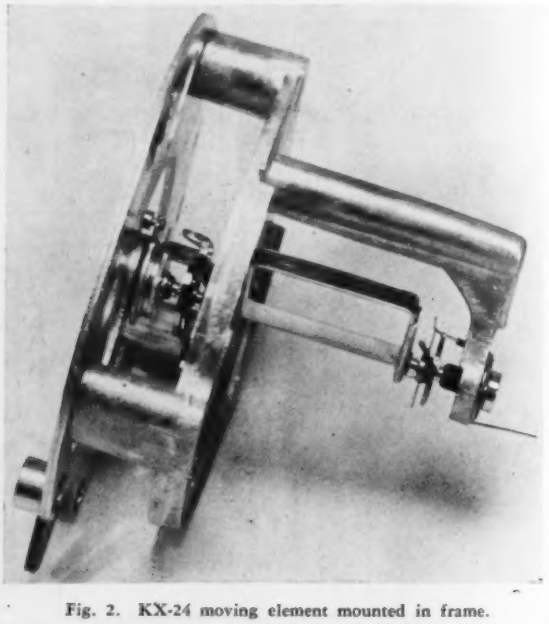

Fig. 2. KX-24 moving element mounted in frame.

After unsoldering the upper and lower springs from the outer springholder arms, and loosening the upper and lower jewels sufficiently, the movement can be removed from the element frame from the lower side. *Be sure the top jewel is not removed from its assembly* as it is very difficult to reassemble this spring-type arrangement of jewel- and zero-adjustment construction. In reassembling the movement, the moving coil should be centered with respect to the inner pole piece by adjusting the lower jewel. The end play can then be set by adjusting the top jewel. It will be noted from Fig. 12 that the conventional jewel-screw lock nut is not required as the jewel screw is kept from turning by the locking effect of the ratchet-type assembly.

The leads from the coil can now be unsoldered from the inner springholder anchors. After disconnecting these leads, the coil can be removed by brushing acetone on the coil brackets to loosen the cement holding the coil in place. When the cement is dissolved, the coil can be removed from the channel-type coil-holding arms. To replace a coil, apply a coat of special household cement to the channel of each coil-bracket arm and a thin coating on the coil. Then carefully insert the coil between the two bracket arms. *Before removing the defective coil, note its position in the brackets as a guide in positioning the new coil.* After positioning the

Fig. 3. KX-24 circular-scale magnet assembly.

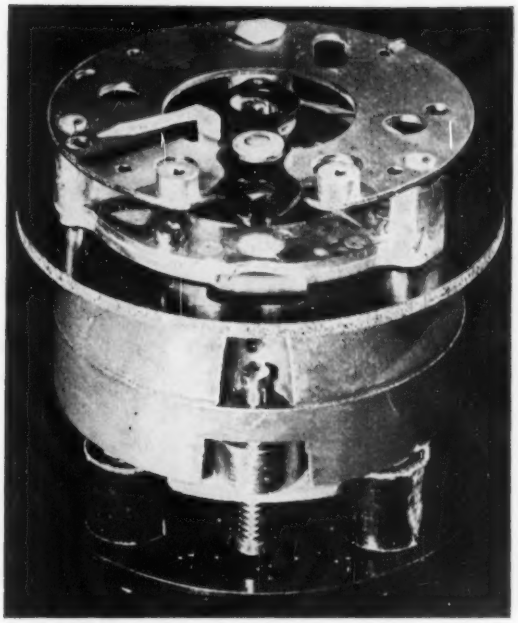

Fig. 4. KX-24 ammeter with dial and case removed.

coil, allow sufficient time to dry, solder leads to spring holders and proceed to reassemble in the reverse order to dismantling.

The element of the circular-scale instrument consists of a shaft with hard steel pivots pressed into shaft at both ends. The shaft is knurled to hold the upper and lower coil-bracket arms, both of which are pressed on the shaft. The top bracket assembly includes the coil holding arm—staked to the lower end of the shaft bushing—the cross arms with balance weights and counter weights. A bushing-type stop is pressed on the shaft just above the spring. The lower spring assembly consists of a bushing to which is staked a mica washer, the spring holder, fiber washer and metal washer. This assembly is then pressed on the shaft.

Spring-type jewels can be used in these instruments. The lower jewel assembly consists of a spring holder, insulated from the frame by paper washers and bushings, a crimp washer, and a spanner nut. *The lower spring holder is not adjustable.* The upper spring holder is a rachet-type arrangement for movement of the spring position after spring adjustments. The upper jewel assembly consists of the jewel-screw, crimp washer, ratchet-type adjuster arm, rachet-type spring holder, spanner-type bushing, spanner-type jewel nut, and a spanner-type bushing riveted to the top bridge. The parts are assembled in a fixture at the manufacturer's for positioning of threads and for pressure. The zero-adjuster arm is attached to the frame (over a bushing) by one screw. The pin in the zero arm is set in the fork of the zero adjuster before positioning on the shoulder bushing and assembling the holding screw.

The magnet assembly consists of a circular cobalt magnet with inner and outer pole pieces as shown in Fig. 10. The outer pole piece is welded to the magnet while the inner pole piece consists of a stack of laminations riveted to the magnet. Four insulated mounting posts are assembled in the lower side of the magnet for use in mounting the mechanism to the base. The magnetic shunt is assembled to the magnet by three screws, one having a spring arrangement to allow for adjustment of shunt position. The position of the magnetic shunt with respect to the magnet is variable and is changed by the screw arrangement. A fiber ring-type washer is placed around the magnet to prevent a shifting of the mechanism in the case if the instrument is subjected to a heavy shock.

High-shock instruments are made dust-proof by cork gaskets at cover-to-case and case-to-base assembly points.

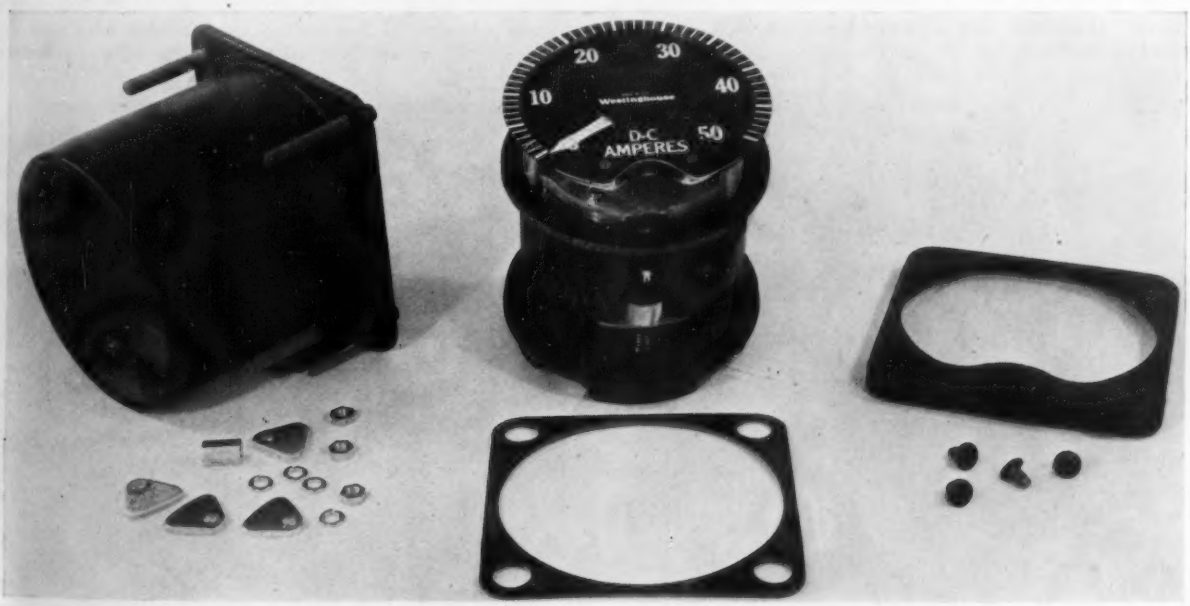

Fig. 5. KX-24 ammeter with case and cover removed.

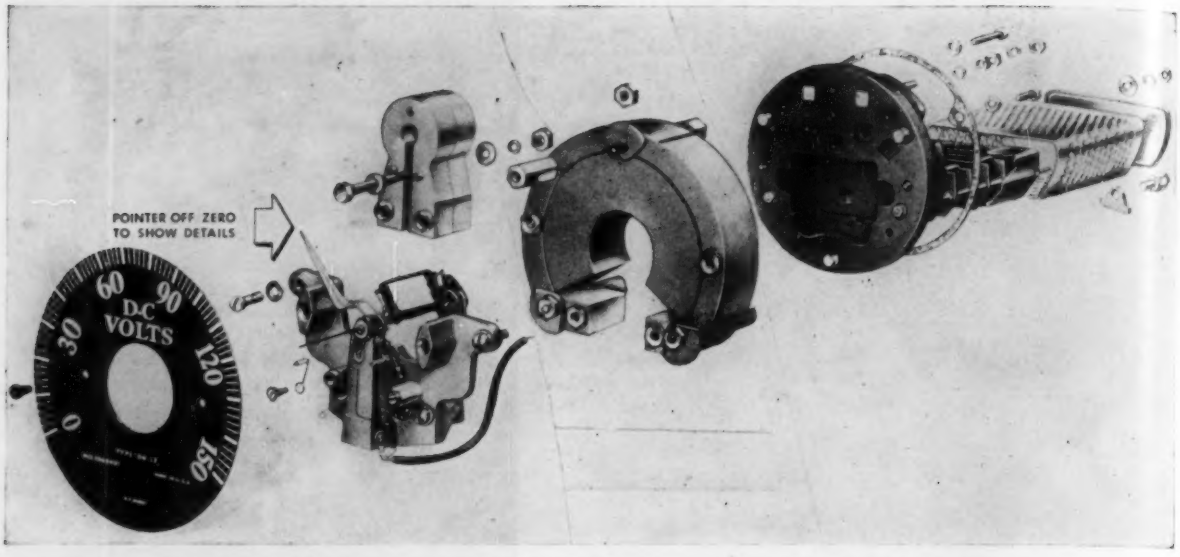

Fig. 6. Exploded view of General Electric DB-12 voltmeter showing the details of its assembly.

DB-12 Instrument

To detach the case of the DB-12 instruments shown in Figs. 6, 7 and 8, the four cover screws and three case-to-base screws must be removed. The dial is attached to the element frame by two screws.

The element can be dismounted from its magnet assembly by removing the four element-bracket-to-magnet screws at the top of the die-cast bracket, and unsoldering the leads. A convenient and safe method of removing the element from its magnet assembly is to insert studs about two inches long in place of each of the four mounting screws as they are taken out. These studs act as guide posts for sliding the element up and out of its assembly, thereby protecting the movement from possible damage if the poles of the magnet (the core is one pole) are forcibly attracted to each other as the element is removed. This caution is suggested since the movement cannot be removed from the element until the element is detached from the magnet. Since this instrument has an open type magnet (see Fig. 6) a keeper should be inserted between the magnet poles as the element is removed. A keeper can be made from a piece of one-eighth-inch flat soft iron, shaped similar to the core and core arm so that the magnet pole and the steel shell can be closed as the core is removed. To reassemble the element in the magnet, the guide studs will serve to position the core accurately as the keeper is removed. When the element is positioned, the studs should be removed, one at a time, and the screws inserted.

With the element out of its magnet assembly, the move ment is removed by detaching the core (three screws), u soldering the outside ends of the springs, and loosening th jewels to clear the pivots. The inside ends of the spring are soldered to a split-type sleeve collet that slides on th movement shaft and is held in position by friction. Th pointer and cross arms are staked to a bushing presse in position on the shaft. The hard steel pivots in the end of the element shaft are a press fit. A counterweight i assembled to the tail of the cross arms and wire-woun balance weights are used for final balance adjustments.

Fig. 8 shows the base assembly details of the d-c. volt meter. The ammeter base assembly is similar except for th resistor mounted on the back of the base.

Test and Inspection

The calibration and test adjustments of these long-scal instruments are easy to make. These operations consist o both mechanical and electrical adjustments such as balance end play, continuity of electrical circuits and calibration

A mechanical inspection should always precede any cal bration adjustments to ascertain if the instrument is devoi of friction or sticking, all moving parts have sufficien clearance, the instrument is clean, all connections tight, etc

Clearance of moving parts is very important from th standpoint of friction and sticking. A few of the clearanc points to check in this type of instrument are: coil in ai gap, pointer on scale, pointer on spring holder, spring co

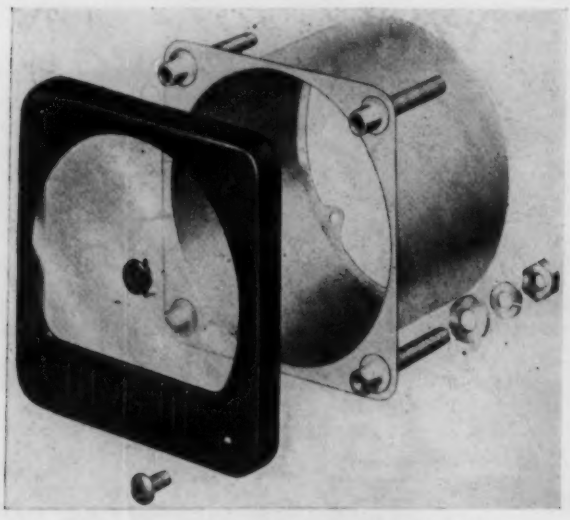

Fig. 7. Cover and case of the General Electric DB-12.

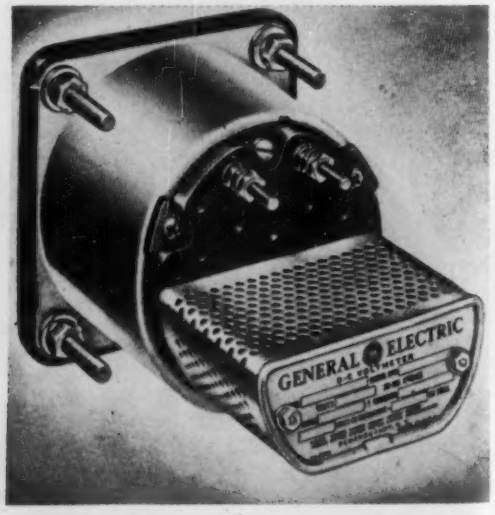

Fig. 8. Base assembly details of the General Electric voltmeter.

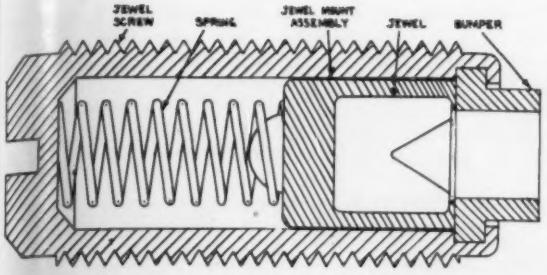

Fig. 9. Construction of spring-type jewel mounting used in KX-24 instruments.

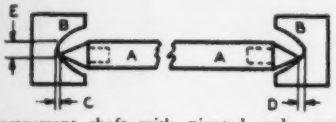

Fig. 10. Instrument shaft with pivoted ends, resting between two sapphire jewels.
A—Shaft with pivoted ends.
B,B—Sapphire jewels.
C+D—Total end play or movement of shaft end to end.
E—Side play, or distance pivot can move from one side of the jewel to the other.

lutions, spring on adjacent parts, and shaft on inner pole ece. Bumper or pointer stops should be set a sufficient stance below zero and above full scale to allow the pointer pass these points. The inside bumper should be set ightly in front of the outside bumper to take the first ock of the pointer. Pointers sticking on bumpers are not common, hence this condition should be checked. Moisre or other foreign substances on the pointer or bumper ad at the point of contact is often the cause of sticking. e effective method of checking and cleaning air gaps is place a piece of white paper between the magnet and e base. The white paper serves as a background and a flector, greatly improving the degree of detection of even e smallest particles.

End play is the end-to-end movement of the element shaft tween the jewel bearings. See Fig. 10. This adjustment is one of the most critical operations in the assembly of this instrument. Owing to the spring-type jewels used in high-shock instruments, the spring effect of the jewel is often mistaken for end play. Friction may result from this misjudgment: lack of free end-to-end motion of the shaft. The end play of this instrument should be of the order of two to five thousandths of an inch. This allows for sufficient end play and yet not to such a degree that the element will sag and rub on adjacent parts. End-play adjustments should be made by bringing the jewel screw down slowly toward the pivot until the prescribed clearance is reached. Fig. 11 shows a convenient method of adjusting end play by judging the side play. The picture explains this method clearly. Another method of adjusting end play is by inserting the flat end of an air-gap cleaner between the coil frame and the top of the inner pole piece and moving the coil up and down as the jewel is adjusted.

Element balance is important in instruments from the standpoint of scale distribution. When these d-c. high-shock instruments are calibrated, the pointer is set on zero in the face-up position and balanced in four positions: pointer horizontal left and right, and vertical up and down. See Fig. 12. The pointed should be on zero in the normal operating position and within one thirty-second of an inch in all other positions. Any deviation from these balanced conditions indicates that a change has taken place and that the element should be rebalanced. Wire-wound balance weights are used on this type of instrument. These weights can be shifted by gripping them with tweezers along the length of the weight, is shown in Fig. 13 and sliding them in the desired directions.

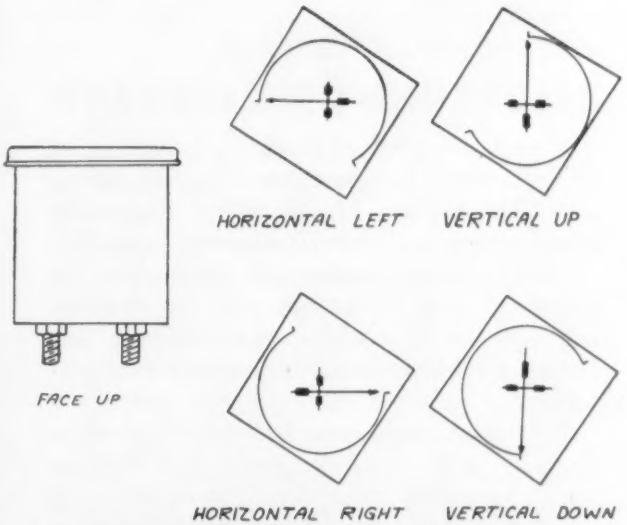

Fig. 12. The moving element of d-c. high-shock instruments is balanced by first setting the pointer to zero with the instrument in the face-up position. Then the instrument is turned on its side to the four positions shown. The pointer should read zero in the normal operating position and should deviate not more than one thirty-second of an inch in the other positions.

Fig. 11. Method of end play adjustment.

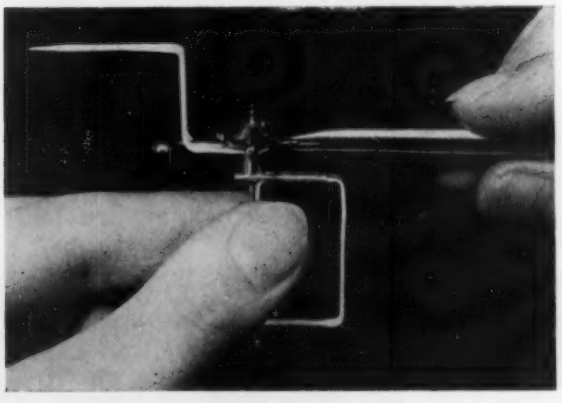

Fig. 13. Correct method of shifting balance weights.

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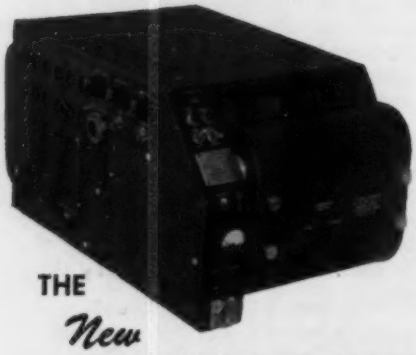

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The electrical adjustments of these instruments vary depending upon whether they are ammeters, voltmeters, millivoltmeters, temperature indicators, etc. The adjustments are: magnetic shunt, electrical shunt, spring, swamping resistance and series resistance. The magnetic shunt is common to all kinds of KX-24 instruments but is not found in the DB-12 type. Final electrical adjustments

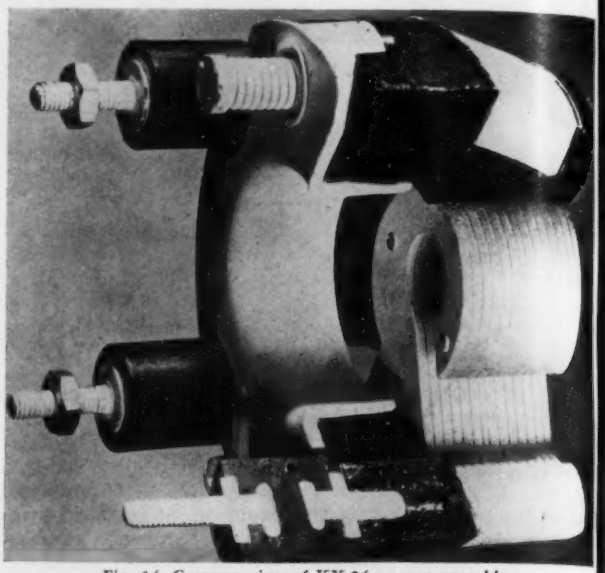
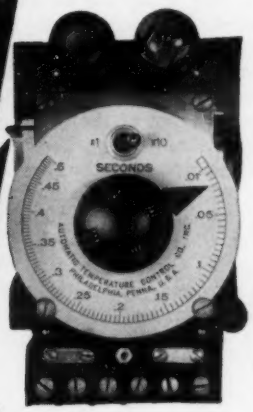


Fig. 14. Cutaway view of KX-24 magnet assembly.

Fig. 15. Magnetic shunt adjustment of KX-24 ammeter.

ELECTRONIC TIMER



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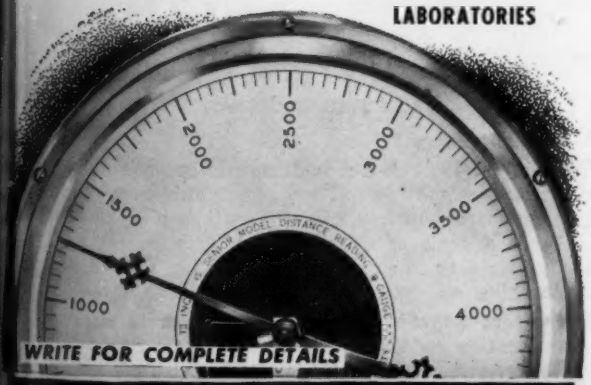

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should be made with the cover on the instrument, as the cover may alter the instrument calibration by one percent or more.

The magnetic shunt is located on the under side of the magnet as shown in Fig. 14 and is adjusted by means of a screw-type pusher rod. The screw adjuster is accessible from the front of the instrument when the cover is removed. The adjuster screw head lies directly behind the hole in the lower part of the zero adjuster. With the zero adjuster centered, its hole is a guide for the screw driver when setting the magnetic shunt. See Fig. 15.

Electrical shunts, either internal or external, are calibrated at the factory and should not be changed unless as an emergency measure. Filing a shunt, that is, removing material, increases its resistance and hence its voltage drop for a given current. Such filing is done only as an emergency measure while waiting for parts. If a lower voltage drop is required, the application of solder on the shunt blade (also an emergency measure) will decrease the shunt's resistance. *This method of correction should not be generally practiced, however, as undesirable thermal effects may result, causing errors in the instrumental readings.*

As these instruments are spring-controlled, it is self-evident that any change in spring torque will effect calibration. The outer end of the spring is soldered to the post of the zero adjuster, therefore this bond must be broken to change the length of the spring and hence its torque. To reset zero after spring change in the KX-24 instrument, the ratchet-type spring holder is moved while holding the zero adjusting arm at the center position. In the DB-12 instrument, the split-type spring collet is shifted on the movement shaft.

Swamping resistance in ammeters and millivoltmeters is the internal resistance (usually a pigtail) in series with the moving coil of the instrument. Its purpose is to reduce the temperature-error effects of the copper-moving coil. It can also serve as a means of making slight calibration adjustments. In millivoltmeters of the KX-24 type, the swamping resistance is adjusted in series with the element to a given value (2.08 ohms) so that at 50 millivolts the full-scale current of the instrument is 24 milliamperes. Full-scale adjustment at 24 milliamperes is made with magnetic shunt. The swamping resistance of the DB-12 instrument is the spiral or spool on the inner side of the base or on the front of the frame (not the flexible spiral lead connected to the front zero adjuster).

The series resistance of the KX-24 voltmeter is internal up to capacities of 750 volts. The wire-wound resistor spools have a baked varnish finish and should never require adjustment. Should an adjustment beyond the range of the magnetic shunt be necessary, a resistor of different ohmic value should be used. The resistance cards in the rear of the DB-12 voltmeter can be adjusted to correct errors of calibration.

If the DB-12 instrument is found to read high on one side and low on the other, the core-to-frame screws can be loosened and the core shifted to the side that reads low. The core screws should then be tightened and the instrument rechecked.

Principles of Operation

KX-24 Instruments

The new high-shock d-c. instruments operate on the permanent-magnet moving-coil principle. This new single-air-gap type instrument has a working air gap of 250 degrees and hence a scale of equal length. This long air gap is made possible by the unique construction of the magnet, collector ring and pole pieces.

Permanent-magnet moving-coil instruments depend for their operation on the interaction of the flux or lines of force between the permanent magnet and the moving coil. In this high-shock instrument, we have an active air gap of 250 degrees, that is, a constant field between poles over the full length of the air gap. With this constant permanent-magnet field, the degree of deflection of the movement is directly proportional to the current in the moving coil.

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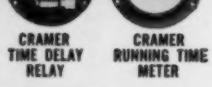

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Current is conducted to and from the moving coil through the two control springs. Electromagnetic damping is obtained by making the bobbin (on which the coil is wound) of aluminum. When this aluminum bobbin moves in the field of the permanent magnet, voltage is induced in the bobbin, causing current to flow and hence a magnetic field to be created about the bobbin. This field opposes the field of the magnet and damps out oscillatory motion.

The magnetic circuit can best be understood by referring

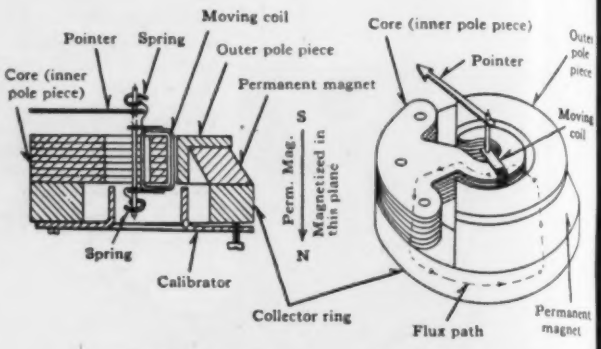

Fig. 16. Sketch showing the magnetic circuit and theory of operation of the KX-24 d-c. instruments.

to Fig. 16. This pictorial representation also shows the magnet construction and theory of operation of the d-c. circular-scale instrument.

DB-12 Instruments

The DB-12 instrument (see Figs. 6 and 17) also utilizes the permanent-magnet moving-coil type mechanism. This mechanism differs from that of the instrument shown in Fig. 5 in that it has a cross-magnetized, open-type magnet

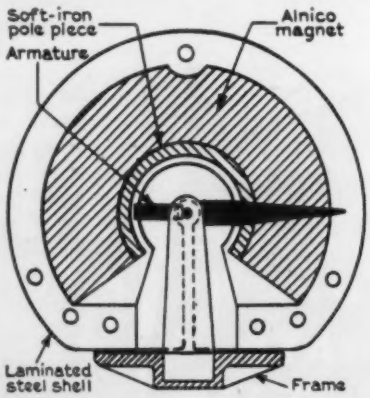

Fig. 17. Mechanism of the General Electric DB-12, d-c. ammeter and voltmeter, shown diagrammatically.

This results in poles covering the full outside and inside circular area of the magnet. A uniform air gap throughout the full travel of the moving coil results from the bonding of the soft iron pole piece to the inner (circular) area of the magnet and the core assembly that completes the laminated steel shell attached to the outside circular area of the magnet. The steel shell acts as a magnetic collector ring and also effectively shields the element from stray fields.

Maintenance

Long life and efficient service from electrical measuring instruments depends to a large extent on the care they are given. Circular-scale instruments, although superior in design and embodying the best of materials, are no exception to this rule. They are, however, less susceptible to damage due to rough handling; but misapplication and accidents do sometimes relegate these instruments to the inactive list. It is for these reasons that the following suggested items of possible defects and corrections are given.

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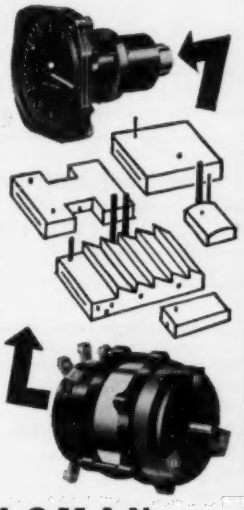

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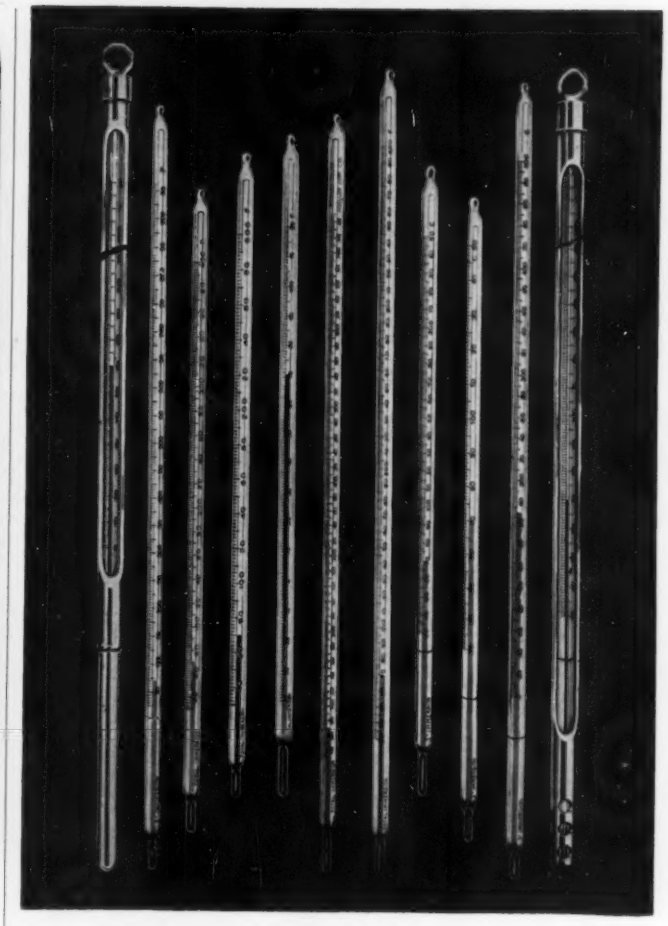

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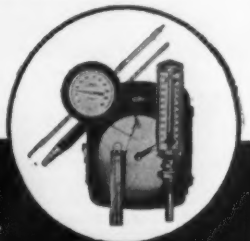

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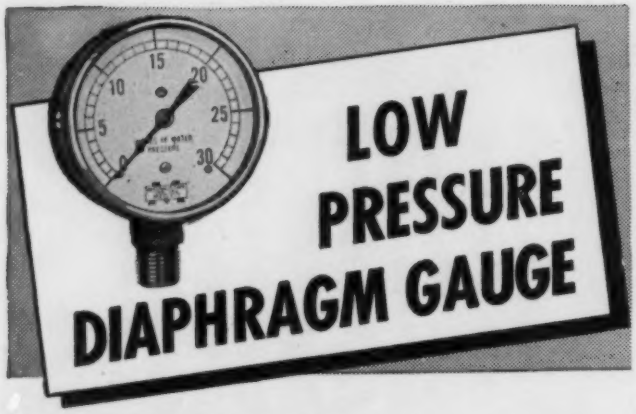

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S-6	1/1000 min.	10 min.	±.02 sec.	$60.00
S-1	1/100 sec.	60 sec.	±.01 sec.	$60.00
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THE *Standard Electric Time Co.*

SPRINGFIELD 2 STANDARD FOUNDED 1926 **MASSACHUSETTS**

Symptom: Instrument Fails to Indicate

POSSIBLE DEFECT	
MECHANICAL	ELECTRICAL
Pointer sticking	Open element
Bobbin sticking	Open series resistor
Element out of jewels	No external circuit
Pivots tight in jewels	Mechanism shorted
	Open thermocouple
	Open rectifier

Symptom: Instrument Indicates Incorrectly

POSSIBLE DEFECT	
MECHANICAL	ELECTRICAL
Friction, rolling or static	Poor connection
Sticking up scale	Ground
Spring convolutions touching	Partial short
Off balance	Wrong connection
Bent pointer	Magnet weakened
Off zero	Shunt connection broken
Spring set	Temperature error
Spring loose on shaft or holder	External field effects
Loose pointer	Static effects (glass)
Loose pivots	Magnetized pivots
Loose jewels	Shorted resistor
Pointer does not pass full-scale and zero	Defective photocell
Wrong end play	Defective thermocouple
Warped base	Defective thermoelectric circuit
Element or dial shift	Reversed polarity
Parallax	Steel panel mountings
Pointer vibrating	Misapplication (AC-DC pulsating)
Magnetic dust particles in air gap	

TROUBLE CHART FOR D-C. INSTRUMENTS

As friction is probably the worst enemy of the electrical instrument, we will make this our first item. Little if any trouble due to pivot and jewel causes is encountered in high-shock instruments. The spring type jewel and shaft bumper design account for this favorable condition. Carelessness in adjusting the end play can cause some pivot friction, that is, if the shaft is tight between the jewels. Excessive end play may allow the element to angulate and rub on adjacent parts. If jewels are stocked as spare parts, be sure they are kept clean, as dirt or moisture in a jewel housing may cause the jewel to stick if compressed.

Other points to check as possible causes of friction or sticking are: spring convolutions touching or sticking, foreign material in air gap, moving parts such as pointer, coil, shaft, etc., rubbing on adjacent parts, and pointer sticking to bumper.

Failure of an instrument to indicate may be due to an open external circuit; therefore, it is well to check this condition before opening an instrument. A completely shorted coil will also be evidenced by a lack of pointer indication. Open coils and resistors are often the result of misapplication or excessive overloads. These points should be checked with an ohmmeter or other suitable means when an instrument fails to indicate.

Inaccurate indications might be due to a multiplicity of causes. A few of the most common of these causes are poor connections (especially in millivoltmeters), partial shorts in coils and resistors, weakened magnets, defective balance, zero shift of pointer, defective shunt, etc.

Millivoltmeters are calibrated with leads having a resistance as indicated in the calibration data on the dial plate of the instrument. If leads having other than this resist-

An Important Announcement From The Ford Motor Company

Since 1923, we have manufactured and distributed the world-famous Johansson Blocks.

We now have completed negotiations for the sale of the Johansson Gage Division of the Ford Motor Company to Brown & Sharpe Manufacturing Company of Providence, R. I. Before this transaction was completed, we gave very careful consideration to the problem of finding a company with the skill and experience that would assure continued production of Johansson Blocks to the Johansson standards of quality.

The Brown & Sharpe Manufacturing Company has 115 years of experience in the making of precision tools, and after careful study, we decided that this experience, coupled with their standing in American industry have made them the sound choice to take over the manufacture of these precision gages.

All patents, methods and machines required for making Johansson Blocks become the property of Brown & Sharpe. Machinery and special steel stocks are being moved to Providence.

Meantime we will continue to provide Johansson Blocks from available finished stock here at Ford until Brown & Sharpe are in operation and ready to supply them.

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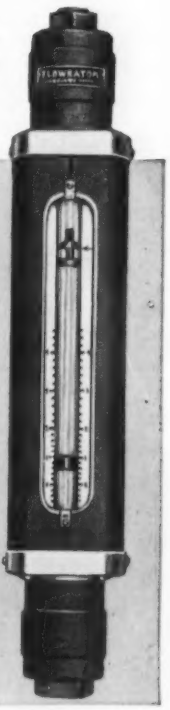
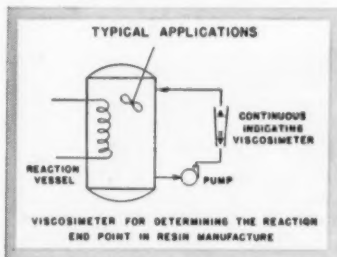
CONTINUOUSLY AUTOMATICALLY

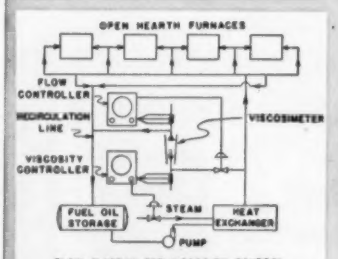
(and with automatic control of the viscosity, if desired) RIGHT IN THE PIPE LINE, WITHOUT WITHDRAWAL OF FLUID SAMPLES, WITHOUT STOP-WATCH READINGS OF EFFLUX TIMES NOW AN ACCOMPLISHED FACT

Viscosimeters have graduated from the class of laboratory test instruments to full-fledged industrial instruments which perform their function without manipulation by an operator, just as temperature, pressure, flow and level instruments have been doing for many years.





VISCOSIMETER FOR DETERMINING THE REACTION END POINT IN RESIN MANUFACTURE



FLOW DIAGRAM FOR VISCOSITY CONTROL OF OPEN HEARTH FUEL OIL

PRINCIPLE OF OPERATION

Continuous viscosimetry has been accomplished by utilizing one of the unique properties of the F & P FLOWRATOR meter (formerly rotameter): ability to make metering floats either viscosity sensitive or viscosity immune. Into one FLOWRATOR are placed two metering floats, the one so shaped that it is very viscosity sensitive, the other one with the patented F & P viscosity immune shape. When fluid flows upward through the tapered metering tube both floats will, of course, rise in the normal manner. However, the elevation of the one float will be relatively slight, since it is produced solely as a function of fluid flow rate. The other float elevation will be much greater since it is a function both of viscous drag and flow rate. The space increment thus created between the two floats is a direct measure of viscosity. By selecting any particular flow rate which will give a convenient elevation of the one float to serve as a reference line, the other float elevation may be marked as viscosity graduations in terms of centipoises, centistokes, S.S.U. or any other desired units. Viscosity measurement all the way from .0008 to 800,000 centipoises is now possible.

Write for catalog 88 giving much additional information. F&P VISCORATOR continuous viscosimeters have been thoroughly tested in trial installations for well over a year.

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The Golay

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During the war years great forward strides were made in this field, particularly with respect to the detection and measurement of infra-red radiation. At the March 1946 meeting of the American Optical Society, held in Cleveland, much of this progress was revealed.

Of particular interest to those present was the disclosure of the Golay infra-red detector, developed at the Signal Corps Engineering Laboratories under the direction of Dr. Marcel J. E. Golay. This device was acclaimed as presenting the best all around characteristics of sensitivity, speed, reliability and spectral uniformity of response.

The Eppley Laboratory, Inc. manufactures the Golay detector under the personal supervision of Dr. Golay. Literature is available upon request.

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For complete details write: Dept. A, Dexter & School Sts., Watertown, Mass.

Standard & Special Thermostats & Pressure Switches

ance value are used, the calibration of the instrument will be affected.

CONNECTIONS

External and internal connections of the high-shock instrument are similar to those of other permanent-magnet moving-coil types. The various connections are best explained diagrammatically in Figs. 18, 19, 20 and 21.

To be continued

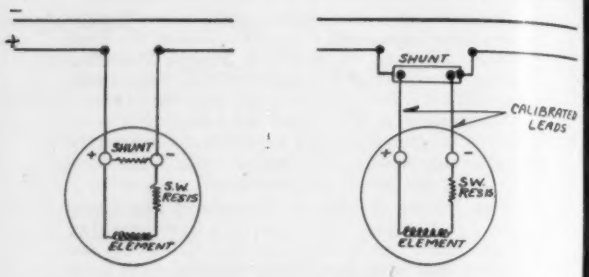

Fig. 18 *(left)*. D-c. ammeter and milliammeter connections for self-contained instruments. Fig. 19 *(right)*. D-c. ammeter connections when external shunt is used.

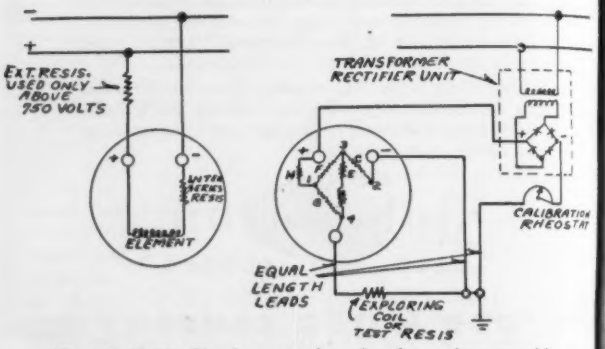

Fig. 20 *(left)*. Circuit connections for d-c. voltmeter with or without an external shunt. Fig. 21 *(right)*. Circuit connections for a resistance thermometer indicator.

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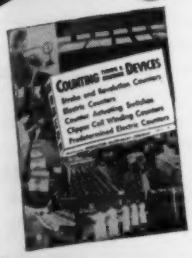

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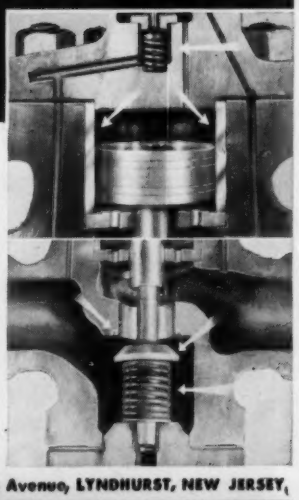

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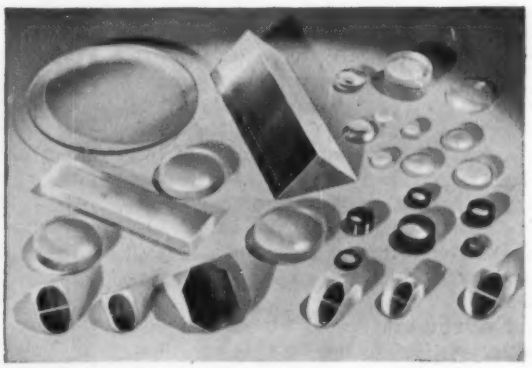

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INSTRUMENTS ON THE MARCH

New UAL Base Largely Automatized

SAN FRANCISCO.—Hailed as the world's finest and most modern, a 116-acre "push button" airline maintenance base with 700,000 square feet of buildings has been completed by United Air Lines at the north end of San Francisco's Municipal Airport and today is contributing its full share to top-flight operating efficiency. This veritable aircraft factory, where as many as 11 Mainliners can be overhauled simultaneously, is declared to be at least seven years ahead of its time.

Most spectacular innovation is a "push button" maintenance dock embodying a system of suspended metal catwalks which completely surround each DC-6. Within ten minutes from the time the giant craft first noses its way through the big hangar door, as many as 50 expert workers swarm all over it. Everyone knows his particular task. Electric hoist operators prepare to lift the four engines off their mounts even as mechanics are unfastening connections. Instrument, radio and servomechanism technicians start taking out equipment which will go to their respective shops.

Engines are moved on engine and mount dollies to the vast power-plant department. After a quick steaming to remove outside grease and dirt, the engines are disassembled and parts are strung along a 1,280-foot overhead chain conveyor. Into a 160-foot long washer tank go the parts, to emerge five hours later, absolutely clean. Parts are then tested for dimensional changes to 0.001" and for flaws—visible and invisible—by means of an array of instruments. Parts are replaced primarily on the basis of their condition, regardless of the time they have been in service. Thus a Mainliner engine becomes virtually new after every five or six overhauls.

After reassembly of the engines, they are taken to the test-cell building where they are run-in for 4½ hours before being recertified. Refrigeration and heating equipment, and numerous instruments, permit technicians to determine engine performance under the widest range of climatic conditions.

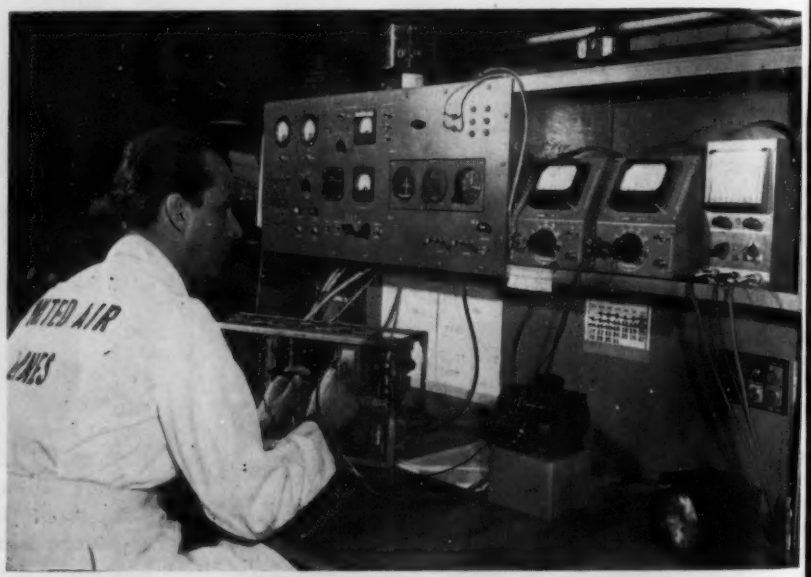
In a shop adjoining the test cells is something else new to airline maintenance—80 tons of machinery and instruments employed in checking the functioning of carburetors under flight conditions. Altitudes of up t 50,000 feet can be simulated.

Propeller servicing is equally thorough. For example, electric de-icer boots are checked by means of electrical instruments. Reassembled propellers are checked and adjusted in a special balancing room.

Instruments, radio equipment, electrical and hydraulic devices from the Mainliner go to a department which is as vast as it is intricate. In the instrument section an electric-grid filter removes dust from the air and blowers keep the room pressure slightly above atmospheric so there will be no chance for dust to seep in when doors are opened.

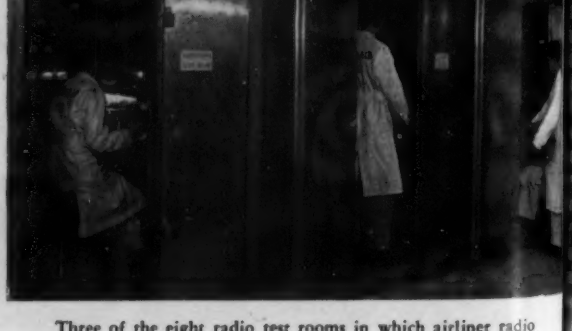
In this department, radio sets are calibrated in specially insulated rooms; altimeters are reset in special decompression chambers; generators and hydraulic systems are checked, and automatic pilots are tested on special benches.

Test pilots take the Mainliner aloft for a four-hour check flight after overhaul. Accompanying the flight are technicians who check the functioning of radio, instrument and electric equip-



TESTING ROBOT PILOT: A radio-electrical expert at United Air Lines' San Francisco maintenance base checks the amplifying unit of a Sperry automatic pilot.

San Francisco maintenance base of UAL where 11 Mainliners can be overhauled simultaneously.



Three of the eight radio test rooms in which airliner radio sets are overhauled. See cover photo for details.

DUST-FREE INSTRUMENT SHOP in United Air Lines' San Francisco maintenance base. Air pressure is kept slightly above atmospheric. An electric grid precipitator also filters the air.

nt which has gone through their ps.

Construction of the base began as g ago as 1940 and its development s pushed in 1942 when United began ing four-engined planes across the Pacific under contract for the Army Air Transport Command. Latest additions were started about a year ago. Chiefly responsible for design of the base was Nicholas Boratynski, regional engineer for United.

Strain Tester for Rubber

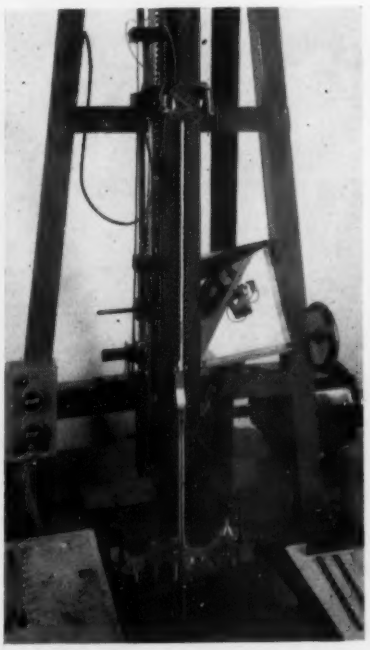
WASHINGTON, D. C.—A new de- developed at the National Bureau Standards conveniently measures TRAIN in vulcanized rubber, in contrast conventional tensile testers which ermine tensile STRESS. In this ap- atus the strain is measured at a nite time after application of a determined stress, while the usual ing method employs essentially the posite procedure, that is, measure- nt of stress at a specified strain. ignated therefore a "strain tester," development followed Bureau inves- tions which revealed that the new nique combines a higher degree of roducibility in measurement with an uracy not previously possible.

uring the past three years, accord- to Technical Report 1238, both ain and tensile tests have been made the Bureau on several hundred ts of various lots of GR-S, GR-I GR-M synthetic rubbers. Statis- l analyses of these data have shown t variances introduced by the strain are negligible compared to the iances in different sheets of rubber n the same batch, or in batches from same lot of polymer.

ince twenty specimens for the strain can be cut from a single test sheet, comes possible to detect differences he properties of rubber from differ- parts of the sheet, or to study the t of aging on stiffness or modulus means of a single test sheet. Fur- more, the relatively large distance ween bench marks on the specimens in the new test and the fact that test subjects them to a uniform s for a definite length of time make specimens desirable for measure- ts of set. Values determined in this ner are found to be much more re- ducible than the usual measure- ments made after rupture of the specimen.

The strain tester was designed to incorporate this improved reproducibility of measurements and high degree of accuracy in an apparatus suitable for routine testing. The design features responsible for the precision and accuracy are:

(1) Observation of bench marks when they are essentially at rest;



This view of the NBS rubber strain tester, taken from the perspective of the operator, shows the optical prism, the rubber specimen in test position, and the mirror in which the upper bench mark is observed. Note also the weight-selector keyboard, lower left.

(2) Use of freely-suspended weights to attain the desired stress without frictional effects; and

(3) Increase in the distance between bench marks of four times that employed for the usual dumbbell-shaped specimens.

In addition, the various manual operations in the test are simplified.

The tester is composed of two parts, built into a supporting table:

One part, above the table, includes a mechanism for extending the specimen, an optical system for observing the upper bench mark on the specimen from a seated position, a mechanism for aligning a millimeter tape with the bench marks, a time cycle controller for regulating the sequence of operations, and a keyboard for selecting the load to be applied to the specimen.

Beneath the table is the mechanism for applying the selected load. This mechanism employs eight solenoids for adding eight different weights singly or in combinations to a weight assembly attached to the specimen.

The rubber specimens are strips 0.254″ wide and 6″ long, cut from the usual 6″ square test sheet. The specimen die consists of six razor-blade strips clamped between metal spacers. Thus, five specimens are cut in a single operation. The bench marks, placed on the specimens in the usual manner, are spaced 10 cm. apart. Using a special thickness gage, the average thickness of the specimen between the bench marks is obtained by a single measurement. The gage reading is entered on the keyboard of the strain tester.

After placing the specimen in the grips, the starting switch is pressed, causing the selected weights to be added to the weight assembly and starting the motor which pulls the specimen upward. When the specimen lifts the weight assembly from its support, a switch starts the time cycle controller. At subsequent predetermined intervals this controller:

(1) Halts the upward travel of the specimen by stopping the motor when the weight assembly has been lifted sufficiently to prevent it from coming back to rest on its base as the specimen continues to stretch,

(2) Signals the operator and lights the lamps in the optical system for observing the upper bench mark and hair line,

(3) Extinguishes the lamps to prevent late observations,

(4) Returns the specimen and weights to their starting positions by starting the motor in the reverse direction, and

(5) Stops itself at the end of the cycle.

The strain test is not intended to measure stress-strain properties near or at rupture. For control testing, however, and for much research, a knowledge of the strain for any stress below the region of rupture is sufficient.

An examination of strain data, plotted as a function of the time of cure, reveals a rectangular hyperbola of the form $(x-A)\ (y-B)=C$. This observation suggests that strain at a fixed stress decreases with time of cure according to the laws of a second order reaction and therefore strain is a direct measure of the degree of vulcanization. If t, the time of cure, be substituted for x, and E, the strain or

percent elongation, for y, the parameters A, B, and C may be interpreted as vulcanization parameters. In this interpretation A is associated with t_0, *the* time of impending cure or "scorch time"; B with E^{∞}, the elongation for infinite cure or a structure factor; and C with $1/k$ where k is the reaction rate constant. In the case of materials like GR-M, GR-I, or natural rubber, which crystallize on stretching, the scorch time t_0 becomes smaller at stresses where crystallization begins and becomes negative for greater stresses. It is also noted that these parameters are greatly affected by small variations in the test data. Since data from different test sheets of the same compounded batch and data from different batches of the same lot of polymer show rather large variances, several batches must be tested in order to obtain sufficient data for reliable parameters.

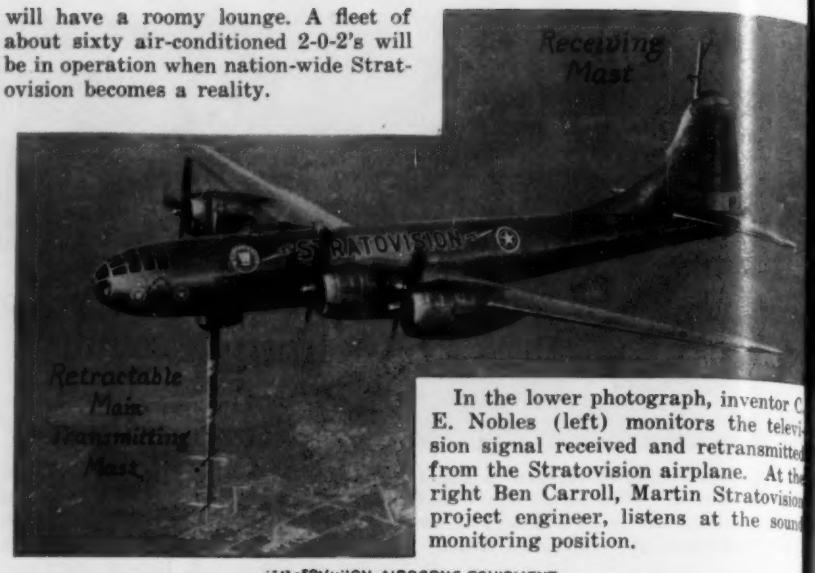
"Stratovision"

ZANESVILLE, Ohio. — Television broadcasts of the Republican National Convention beamed from the world's first airborne Stratovision television broadcasting station were received on June 23rd in this rural community—110 miles from the closest ground television station (at Cleveland). Zanesville was chosen for the demonstration by the Westinghouse Electric Corporation and The Glenn L. Martin Company, co-developers of Stratovision, because it is a typical small city surrounded by a large farm area.

At a meeting of editors and writers in the country club, Dr. J. A. Hutcheson, director of the Westinghouse Research Laboratories, and Ben A. Carroll, Martin's Stratovision engineer, explained the long research and development program conducted jointly by the two companies. Then, from the Stratovision airplane flying at 25,000 feet over Pittsburgh after taking off from the Martin airport at Baltimore, C. E. Nobles, Westinghouse engineer who originated the Stratovision system, explained how experimental station W10WXB rebroadcast the convention from the east coast television network.

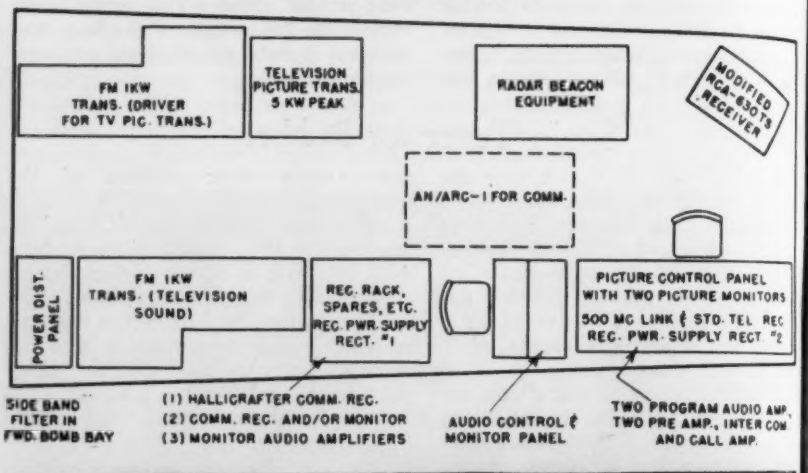
Nobles, 30-year-old Texas-born engineer for whom this demonstration was the climax of a three-year research project, made the announcement on an FM audio wave just before his flying radio station picked up and rebroadcast the convention television program.

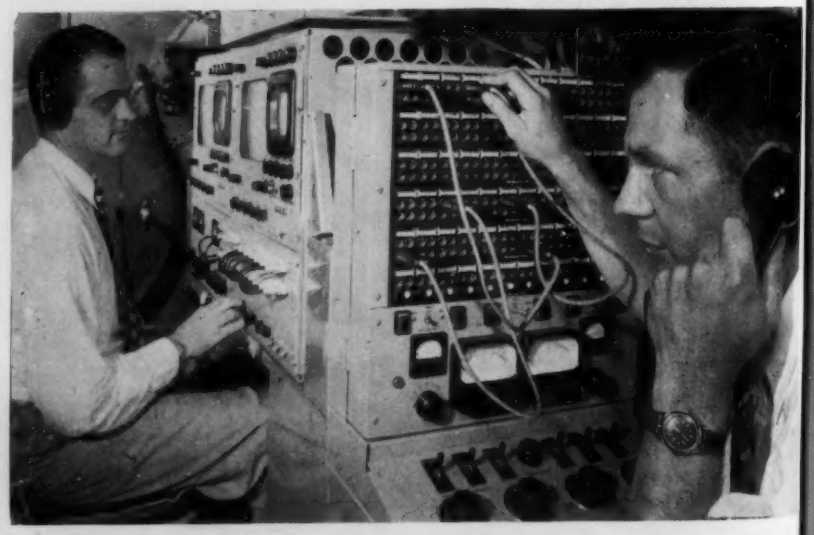
Pictured on this page is the experimental Stratovision station—a modified B-29. In commercial operation of Stratovision, present plans call for using the Martin 2-0-2 airliner modified to meet the needs of this type of operation, and equipped for all-weather flying. The diagram shows the general layout of the equipment in the B-29. Five engineers operate it; only three will be required in the Martin 2-0-2 which provides the right operating performance and economy for such a project—and they and the crew will have a roomy lounge. A fleet of about sixty air-conditioned 2-0-2's will be in operation when nation-wide Stratovision becomes a reality.



In the lower photograph, inventor C. E. Nobles (left) monitors the television signal received and retransmitted from the Stratovision airplane. At the right Ben Carroll, Martin Stratovision project engineer, listens at the sound monitoring position.

STRATOVISION AIRBORNE EQUIPMENT


FM 1KW TRANS. (DRIVER FOR TV PIC. TRANS.)
TELEVISION PICTURE TRANS. 5 KW PEAK
RADAR BEACON EQUIPMENT
MODIFIED RCA-630TS RECEIVER
AN/ARC-1 FOR COMM.
POWER DIST. PANEL
FM 1KW TRANS. (TELEVISION SOUND)
REC. RACK, SPARES, ETC. REC. PWR. SUPPLY RECT. #1
PICTURE CONTROL PANEL WITH TWO PICTURE MONITORS
500 MC LINK & STD. TEL. REC.
REC. PWR. SUPPLY RECT. #2
SIDE BAND FILTER IN FWD. BOMB BAY
(1) HALLICRAFTER COMM. REC.
(2) COMM. REC. AND/OR MONITOR
(3) MONITOR AUDIO AMPLIFIERS
AUDIO CONTROL & MONITOR PANEL
TWO PROGRAM AUDIO AMP., TWO PRE AMP., INTER COM AND CALL AMP.



Tiny Solid Device Can Replace Vacuum Tubes

NEW YORK CITY.—An amazingly simple device, capable of performing efficiently nearly all the functions of an ordinary vacuum tube, was demonstrated for the first time on June 30th at Bell Telephone Laboratories where it was invented.

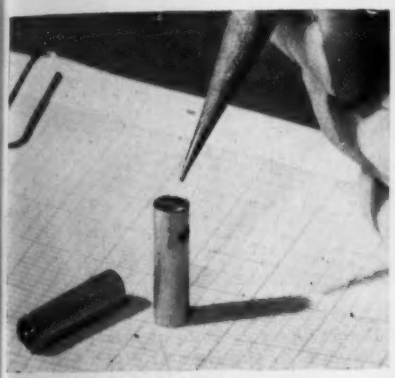
Known as the Transistor, the devi utilizes a principle discovered by t Laboratories in the course of fund mental research into the electrical pro erties of solids. Although the device still in the laboratory stage, Bell scie tists and engineers expect that it m

have far-reaching significance. It will serve as an amplifier or an oscillator—yet it has no vacuum, no glass envelope, no grid, no plate, no cathode and therefore no warm-up delay.

Two hair-thin wires touching a pinhead of a solid semi-conductive material soldered to a metal base are the principal parts. These are enclosed in a simple metal cylinder not much larger than a shoe-lace tip. More than a hundred Transistors can easily be held in the palm of the hand.

Since the device is still in the experimental stage, no data on cost are available. Its essential simplicity, however, indicates the possibility of widespread use with resultant mass-production economies. When fully developed, the Transistor is also expected to find new applications where vacuum tubes have not proved suitable.

Tests have shown that the Transistor will amplify 100 times (20 db) or more. Some test models have been operated as



Transistors, actual size

amplifiers at frequencies up to 10 Mc. Because of the basically simple structure of the new units, stability and long life are expected.

Although many scientists and engineers have been associated with the work, key investigations were carried out by Dr. John Bardeen and Dr. Walter H. Brattain. The general research program leading to the Transistor was initiated and directed by Dr. William Shockley. All three are members of Bell Labs technical staff.

In one demonstration, the audience heard a radio broadcast from a set constructed entirely without vacuum tubes and using instead several Transistors.

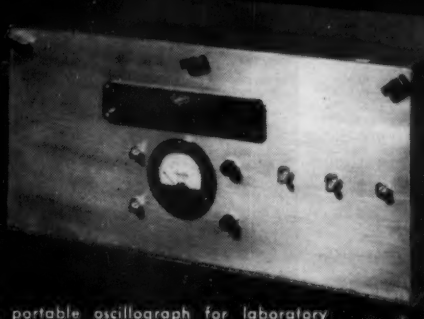
A Transistor was also used to generate a standard frequency tone, thus demonstrating its role as an oscillator.

Because of its lack of a heated cathode delay and other differences, the Transistor can also perform some new functions.

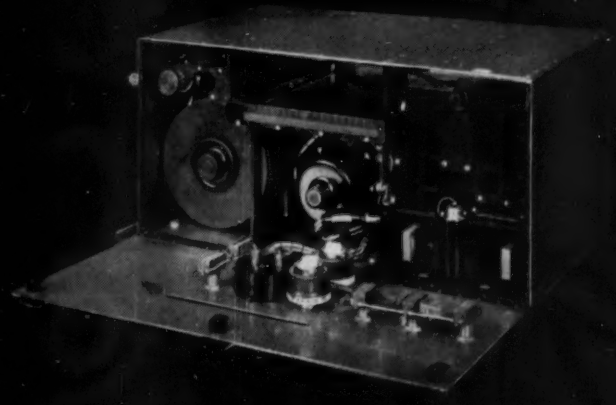
In the Transistor, two point contacts of the "cat's whisker" or detector type, are made to the semi-conductor only two thousandths of an inch apart. Input power delivered to one of these contacts is amplified and transmitted to the other terminal where it is delivered to an output circuit. The Transistor is energized by voltage supplies, such as batteries, which apply bias voltages to

Century

PORTABLE OSCILLOGRAPH



A portable oscillograph for laboratory or field use; this instrument incorporates high standards of accuracy with rugged dependability.



Available with banks of from four to twenty-five hermetically sealed, pencil-type Century galvanometers in a wide selection of frequencies and sensitivities, this instrument faithfully reproduces on positive recording film bearing simultaneously superimposed timing lines.

Paper widths from 35 mm to 6 inches and a wide range of synchronous motor and tuning fork components are available for operation from 110 volts in the laboratory or for 12-24 volts d.c. truck or aircraft operation. Completely portable daylight developing equipment obtainable if required.

A letter of inquiry regarding the application of this instrument to your needs will receive the prompt attention of our engineers.

ANOTHER Century PRODUCT

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the two points. The power actually consumed in the Transistor is less than a tenth that used by an ordinary flashlight bulb.

The amplification process can be understood in terms of the discovery made by Dr. Bardeen and Dr. Brattain that the input point is surrounded by an "area of interaction." Within this area the electronic structure of the semiconductor is modified by the input current. Now, if the output point is placed in this area, the output current can be controlled by the input current.

Semi-conductors have for many years been regarded as an ideal field for research at Bell Telephone Laboratories because of their practical possibilities and rich scientific interest. These materials, whose electrical properties are intermediate between those of metals and insulators, offered particular promise of useful electrical applications, since their ability to carry electrical current can be changed over wide ranges in various ways.

These materials, like any having the ability to conduct electrical currents, rely for conductivity on the presence of current-carrying electrons. In metals there is a ratio of approximately one current-carrying electron to every atom. In insulators, there are practically no such electrons and therefore little conductivity.

In semi-conductors, such as silicon and germanium, some metallic oxides and other compounds, there may be as few as one current-carrying electron for every million atoms. But—and this is the significant feature—this number of carriers may be varied 1000-fold or more by changing the electronic structure of the materials. Hence the current flowing through the semi-conductor can be controlled.

Dr. Shockley had predicted that it should be possible to control the meager supply of electrons inside a semi-conductor by influencing them with an electric field imposed from the outside without actually contacting the material. He devised some experiments to test his hypothesis, but the electrons seemed to get trapped in the surface of the material and did not behave just as anticipated. This part of the problem was tackled on a theoretical basis by Dr. Bardeen, whose theory of what happened at the surface explained satisfactorily many of the observed facts and led to further experiments carried out in collaboration with Dr. Brattain. In the course of these experiments they invented the Transistor.

Transistor action depends upon the fact that electrons in a semi-conductor can carry current in two distinctly different ways. This is because most of the electrons in a semi-conductor do not contribute to carrying the current at all. Instead they are held in fixed positions and act as a rigid cement to bind together the atoms in a solid. Only if one of these electrons gets out of place, or if another electron is introduced, can current be carried. If, on the other hand, one of the electrons normally present in the cement is removed, then the "hole" left behind it can move like a bubble in a liquid and thus carry current.

In a Transistor made of semi-conductor which normally conducts only by the extra electron process, current flows easily into the input point, which is at a low positive voltage, and out of the output point, which is at a higher negative voltage. The area of interaction is produced by "holes" introduced by the input current and collected by the output point.

"NEAREST THING TO FLYING WITHOUT LEAVING THE GROUND." New type of instrument trainer announced by the Special Devices Center, Office of Naval Research. It is an operational craft, built by Link Aviation, Inc., to duplicate in every detail the cockpit of the carrier-based Bearcat fighter (F8F). It is the first Link Instrument Trainer developed to reproduce physical and performance characteristics of a specific aircraft. Advantages of the new craft include acquainting the student, before he enters the actual plane, with emergency procedures and providing him with unlimited experience in "flight." Any type of emergency can be created at will and in safety. A realistic atmosphere is heightened by engine noise, a plane-like vibration, and the drifting of fog over the canopy. Nearly every conceivable airborne annoyance can be effectively reproduced.

DRAWN BY S. E. MITCHELL, DUNBAR, W. VA.

"We'll buy fifty if you guarantee they'll do this when we put each unit on stream."

JOURNAL of the Instrument Society of America

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Vol. 3 | July 1948 | No. 7

General News

ALL SECTION SECRETARIES

Following are this month's changes and additions to be incorporated in the general list of Section Secretaries, Directors and Journal Correspondents which was published in the December 1947 issue of the Journal.

New Jersey—Journal Corres., William A. Hagerbaumer, 401 Birch Place, Westfield, N. J.

Pittsburgh—Journal Corres., M. M. Fromm, 9 Pearl Dr., Pittsburgh 27, Pa.

Official News

RECOMMENDED PRACTICES COMMITTEE MEETING, ST. LOUIS, April 23rd.

Information compiled by three of its subcommittees was validated for publication as tentative recommended practices by the Recommended Practices Committee at the interim meeting in St. Louis, Missouri, April 23.

H. M. McCarthy, Chairman of Sub-committee RP-1, submitted three parts of "Thermocouple and Extension Wire Practices," namely: "Symbols for Types of Thermocouples and Thermocouple Extension Wire"; "Color Coding of Thermocouple Extension Wire"; and "Color Coding of Duplex Insulated Thermocouple Wire."

W. G. Brombacher presented the voluminous "Manometer Tables" compiled by his group, sub-committee RP-2; and R. L. Galley, Chairman of RP-3, "Flow Meter Installation Practices" released tentative practice for "Condensate Chambers-Long Design": "Condensate Chambers-Short Design": "Four-inch Seal Pot"; and "Six-inch Seal Pot."

After the Procedure Sub-committee has completed a standard format for text and drawings and has prepared suitable prefaces for these articles they will be published immediately and distributed to all members for inclusion in the loose-leaf binders issued in the latter part of 1947. Progress reports were made by the Chairmen of Sub-committees RP-4, to RP-9, inclusive, and it appears that work on all projects is progressing satisfactorily. An item of great interest occurred during the progress report for RP-4 "Control Valve and Bypass Practices" when Mr. Paul Elfers outlined what is being done by the National Steam Specialty Club. His remarks were received with great interest.

A tentative code of procedure submitted by the Temporary Sub-committee on Procedures composed of A. E. Krogh, A. F. Sperry and W. A. Wildhack (Chairman) was adopted by the group. This temporary sub-commitee was dissolved and a permanent Procedures Sub-committee with A. F. Sperry as Chairman was set up to carry on and expand the activities in this field.

Vice-president, F. H. Trapnell was requested to write up for the committee a full report on the status of a permanent secretary for I.S.A. and his relationship with the Recommended Practices Committee. Two of the motions passed at this meeting are of particular interest. It was recommended to the Executive Committee that a committee, other than the Recommended Practices Committee, be established to select and issue engineering data to be incorporated in the loose-leaf binders as "Handbook" material. Membership of the Recommended Practices Committee was fixed at twenty-five members having suitably distributed geographical locations and industrial affiliations.

Some eighteen additional topics were submitted as future projects to be worked up by the Committee.—J. G. KERLEY, *Chairman*

RECOMMENDED PRACTICES COMMITTEE AND SUBCOMMITTEE PERSONNEL

The list of members of the Recommended Practices Committee and its several subcommittees has been released and is published herewith:

W. E. Boyle, 821 Hale St., Edwardsville, Ill; W. G. Brombacher, NBS, Washington 25, D.C.; S. C. Chapman, P. O. Box 43, c/o Lago Oil & Trans. Co., Ltd., Aruba, N.W.I.; W. A. Crawford, 806 Woodsdale Rd., Wilmington 280, Del.; Hugh E. Ferguson, 45 East Pershing Rd., Chicago 15, Ill.; W. H. Fortney, c/o Humble Oil & Ref. Co., Baytown, Tex.; H. C. Frost, Corn Products Ref. Co., Chemical Div., Argo, Ill.; R. L. Galley, American Viscose Corp., 35 South 9th St., Philadelphia 7, Pa.; Porter Hart, c/o Dow Chemical Co., Freeport Tex.; David Hostedler, 81 Columbia Heights, Brooklyn 2, N. Y.; P. R. Hoyt, c/o Shell Development Co., 100 Bush St., San Francisco, Calif.; J. Johnston, Jr., 2 Crestwood Pl., Hillcrest, Wilmington, Del.; J. G. Kerley, *Chairman*, 496 Piermont Ave., Hillsdale, N. J.; Anker E. Krogh, c/o Brown Instrument Co., Wayne & Roberts Ave., Philadelphia, Pa.; H. M. McCarthy, Standard Oil Dev. Co., P. O. Box 37, Elizabeth, N. J.; H. F. Moore, Standard Oil Dev. Co., P. O. Box 37, Elizabeth, N. J.; A. V. Novak, Monsanto Chemical Co., Everett Station, Boston 49, Mass.; A. F. Sperry, Panellit Inc., 225 N. Michigan Ave., Chicago 1, Ill.; F. H. Trapnell, 711 Bellevue Rd., Wilmington 280, Del.; R. D. Webb, Carbide & Carbon Chem. Co., South Charleston, W. Va.; J. E. White, Stanolind Pipeline Co., Stanolind Bldg., Tulsa 2, Okla.

RP-1—*Thermocouples and Thermocouple Extension Wire*

H. M. McCarthy, *Chairman*, Standard Oil Dev. Co., Box 37, Elizabeth, N. J.; W. F. Boyle, 821 Hale Ave., Edwardsville, Ill.; G. T. Evans, The Bristol Co., Waterbury 91, Conn.; Prof. C. F. Kayan, Columbia University, Dept. of Mechanical Engineering, New York, N. Y.; A. E. Krogh, C. A. Vogelsang (*Alt.*), The Brown Instrument Co., Wayne Junction, Philadelphia 44, Pa.; J. W. Percy, United States Steel Corp., Research Laboratory, Kearny, N. J.; J. F. Quereau, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pa.; A. P. Steensen, The Foxboro Co., Foxboro, Mass.; L. Van Blerkom, C. J. Tagliabue Corp. (New Jersey), 614 Frelinghuysen Ave., Newark 5, N. J.

RP-3—*Flowmeter Installation Practices Subcommittee*

Mr. H. W. Bocher, 424 Linden Ave., Glenside, Pa.; Mr. C. D. Close, c/o Fluid Controls, Inc., 18 West Chelten Ave., Philadelphia 44, Pa.; Mr. P. S. Dickey, c/o Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio; Mr. R. L. Galley, *Chairman*, American Viscose Corp., 35 S. 9th St., Philadelphia 7, Pa.; Mr. Louis Gess, c/o Brown Instrument Co., Wayne & Roberts Ave., Philadelphia 44, Pa.; Mr. E. F. Kremer, 1019 Culhane Ave., Chester, Pa.; Mr. J. Johnston, Jr., 2 Crestwood Place, Hillcrest, Wilmington, Del.; Mr. H. L. McCully, 161 Windsor Ave., Lansdowne, Pa.

RP-4—*Recommended Practices for Control Valve and By-Pass Manifold Installations*

W. H. Fortney, *Chairman*, c/o Humble Oil & Refining Co., Baytown Tex.; M. K. Anderson, Carbide and Carbon Chemicals, Texas City, Texas; Homer C. Givens, La Gloria Corp., Falfurrias, Tex.; James L. Henderson, Champion Paper and Fibre Co., Pasadena, Tex.; R. H. Koehler, Pan American Refining Corp., Texas City, Tex.; R. D. Mattix, Cities Service Refining Corp., Lake Charles, La.; R. L. Nichols, RuR SR 43, Butyle Plant (H.O.R. Co.), Baytown, Tex.; H. T. Wicker, Standard Oil Co. (New Jersey) Ref., Baton Rouge, La.; J. A. Parker, Shell Oil Co., Box 2527, Houston 1, Tex.; R. L. Nichols, Magnolia Petroleum Corp., Beaumont, Tex.; J. M. Jones, The Texas Co., Port Arthur, Tex.

RP-5—*Instrumentation Flow Plan Symbols*

David E. Hostedler, *Chairman* (Foster Wheeler Corp.), 81 Columbia Heights, Brooklyn 2, N. Y.; S. H. Cope (Hydrocarbon Research Corp.), 77 Hance Rd., Fair Haven, N. J.; Fred L. Crabbe (Malcolm W. Black and Co.), c/o Malcolm W. Black & Co., 41 East 42nd St., New York 17, N. Y.; E. R. Huckman (Foxboro Co.), c/o Foxboro Co., 420 Lexington Ave., New York 17, N. Y.; Harry A. Irving (Taylor Instrument Co.), c/o Taylor Instrument Co., 30 Rockefeller Plaza, New York 20, N. Y.; S. D. Ross (Brown Instrument Co.), c/o Brown Instrument Co., Wayne & Roberts Ave., Philadelphia, Pa.; H. E. Hanson (Standard Oil Development Co.) c/o Standard Oil Development Co., P. O. Box 37, Elizabeth B, N. J.; M. MacDonald (M. W. Kellogg Co.), c/o M. W. Kellogg Co., 225 Broadway, New York, N. Y.

RP-6—*Recommended Practices Pneumatic Transmitter and Controller Usage*

Harry F. Moore, *Chairman*, c/o Standard Oil Development Co., P. O. Box 37, Elizabeth, N. J.; Mr. J. W. Harsch (S.A.M.A. Liaison Member) c/o Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.; Mr. R. E. Hill, Instrument Engineer, Calco Chemical Co., Bound Brook, N. J.; Mr. Ward O'Connor, Lummus Co., 420 Lexington Ave., New York City; Mr. R. V. Rand, 18 - 74th St., North Bergen, N. J.; Mr. Frank J. Sercelj, 700 Suburban Rd., Union, N. J.; Mr. F. H. Trapnell (A.S.M.E. Liaison Member), 711 Bellevue, Wilmington, Del.

Section News

CALIFORNIA

The June 1st meeting of the California Section was held at the Harry Raymond Steak House in San Marino. The program featured a talk by a member of the Section, Mr. G. Foster Rucker, Field Engineer of Leeds & Northrup, on "Development of Self-Balancing Recorders." Also the film "Unfinished Rainbows" produced by the Aluminum Company of America was shown.

DETROIT

The May meeting of the Detroit Section brought another fine talk in this year's schedule. Mr. William T. Bean of the Continental Aviation and Engineering Corp. spoke on "Instrumentation for Experimental Stress Analysis." He covered the use of brittle lacquers, photoelasticity, strain gages, and brittle models. Illustration was provided by slides and some actual samples of work from his laboratory.

The May demonstration was provided by E. B. Anderson Company of Detroit, who displayed electrical recording instruments made by The Esterline-Angus Co., Inc., and megohmers, tachometers and stop watches from the Herman H. Sticht & Co.

The tellers committee reported the results of the spring election. Officers elected are as follows: President, Emil Gillig; Vice-president, William Wilson;

(Continued on page 647)

TECHNICAL SESSIONS FOR THIRD NATIONAL INSTRUMENT CONFERENCE

Program

The technical sessions planned for the Third National Instrument Conference promise to be among the finest ever arranged. Prominent authorities in many fields are cooperating to make this part of the Conference worth the time of anyone interested in instrumentation.

The Program Committees of the Societies cooperating in the Third National Instrument Conference have prepared the programs listed below.

All meetings scheduled on Eastern Daylight Saving Time. Check Bulletin Boards for any last minute changes in meetings.

MONDAY, SEPT. 13—10:00 A. M.

I.S.A. Session on Ordnance Instruments. Room 200. Technical Chairman, to be announced later.

"A Comparison of Small and Medium Power Servomotors," by Robert S. Edwards (Sperry Gyroscope Co., Great Neck, L. I.) Paper No. 48-1-1.

"Photographic Instrumentation Used in the Development of the 'Bat' Missile," by H. K. Skramstad (Guided Missiles Section, Ordnance Development Laboratory, Washington, D. C.) Paper No. 48-1-2.

"Temperature and Pressure Measurements in Rockets," by R. J. Havens (Naval Research Laboratory, Washington, D. C.) Paper No. 48-1-3.

MONDAY, SEPT. 13—2:30 P. M.

A.S.M.E. Session on Temperature and Pressure Elements. Room 200. Technical Chairman, I. M. Stein (Leeds & Northrup Co., Philadelphia, Pa.) Recorder, G. H. Lee (U. S. Naval Academy, Annapolis, Md.)

"Response Characteristics of Resistance Thermometers," by A. J. Hornfeck (Bailey Meter Company, Cleveland, Ohio.)

"Bourdon Tubes in 5000 psi Pressure Transmitters," by O. C. Brewster (Consultant, Litchfield, Conn.)

MONDAY, SEPT. 13—8:00 P. M.

I.S.A. Session on Automatic Control. Ballroom.

"Demonstration of Automatic Control Principles," by Gerald F. Akins, assisted by John H. Kowalski (Eastman Kodak Co., Rochester, N. Y.)

TUESDAY, SEPT. 14—10:00 A. M.

I.S.A. Session on Control Valves. Room 200. Technical Chairman, Paul Elfers (Fisher Governor Company, Marshalltown, Iowa.)

"Valve Characteristics and Automatic Control," by J. G. Ziegler and N. B. Nichols (Taylor Instrument Cos., Rochester, N. Y.) Paper No. 48-2-1.

"Control Valve Body Design," by D. P. Eckman (Cornell University, Ithaca, N. Y.) and R. B. Werey (Conoflow Corp., Philadelphia, Pa.) Paper No. 48-2-2.

"The Liquid Flow Characteristics of a Pipe Line and a Control Valve," by Otto Kneisel (Hammel-Dahl Company, Providence, R. I.) Paper No. 48-2-3.

TUESDAY, SEPT. 14—10:00 A. M.

A.I.P. Session on Scientific Instruments. Room 300. Chairman, Gaylord P. Harnwell (University of Pennsylvania, Philadelphia, Pa.)

"Electron Microscopy," by James Hillier (Radio Corporation of America, Princeton, N. J.)

"The Measurement of the Particle Size of Sub-Sieve Powders," by R. E. Payne (Sharpless Corporation, Philadelphia, Pa.)

"Infrared Instrumentation," by Van Zandt Williams (American Cyanamid Co., Stamford, Conn.)

TUESDAY, SEPT. 14—2:30 P. M.

A.S.M.E. Session on Process Control. Room 200. Chairman, R. L. Goetzenberger (Brown Instrument Company, Washington, D. C.) Recorder, R. W. Hunting (Philadelphia Electric Co., Philadelphia, Pa.)

"The Control Valve in Operation," by W. H. Kidd (formerly Foxboro Co.) and G. A. Philbrick (Research Consultant, Foxboro Co., Foxboro, Mass.).

TUESDAY, SEPT. 14—8:00 P. M.

I.S.A. Session on Electronics. Ballroom.

"Looking into the Future of Electronics," Gordon Volkenant (Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.)

WEDNESDAY, SEPT. 15—10:00 A. M.

I.S.A. Session on Cascade Controls. Room 200. Technical Chairman, Garner C. Parr (Ash Engineering Co., Philadelphia, Pa.)

"The Use of Interconnected Control Instrumentation for Offsetting Unfavorable System Characteristics," by J. A. Pellettere (Gulf Oil Corp., Pittsburgh, Pa.) Paper No. 48-3-1.

"Experimental Application of Combustion Controls to a Process Heater," by W. E. Boyle (Shell Oil Co., Inc., Wood River, Ill.) and P. R. Hoyt (Shell Development Co., San Francisco, Calif.) Paper No. 48-3-2.

"The ABC's of Multi-Element Control," by C. H. Barnard (Bailey Meter Company, Cleveland, Ohio.) Paper No. 48-3-3.

WEDNESDAY, SEPT. 15—10:00 A. M.

A.I.P. Session on Scientific Instruments. Room 300. Chairman, George R. Harrison (Massachusetts Institute of Technology, Cambridge, Mass.)

"The Physical Principles of Vacuum Measurements and Production," by C. H. Bachman (Syracuse University, Syracuse, N. Y.)

"Acoustics Instrumentation," by Richard H. Bolt (Massachusetts Institute of Technology, Cambridge, Mass.) and Richard K. Cook (National Bureau of Standards, Washington, D. C.)

"The Tools of the Physics Teacher," by Richard M. Sutton (Haverford College, Haverford, Pa.)

THURSDAY, SEPT. 16—10:00 A. M.

I.S.A. Session on Control Instrumentation. Room 200. Technical Chairman, A. Novak (Monsanto Chemical Company, Boston, Mass.)

"Supervisory Control Systems," by Louis Gess and R. M. Hutchinson (Brown Instrument Company, Philadelphia, Pa.) Paper No. 48-4-1.

"Pneumatic Transmissions," by Mead Bradner (Foxboro Company, Foxboro, Mass.) Paper No. 48-4-2.

"Instrumentation—By and With Controlled Volume Pumps," by Robert T. Sheen (Milton Roy Company, Philadelphia, Pa.) Paper No. 48-4-3.

THURSDAY, SEPT. 16—10:00 A. M.

A.I.P. Session on Scientific Instruments. Room 300. Chairman, Elmer Hutchisson (Case Institute of Technology, Cleveland, Ohio.)

"Radio Spectroscopy," by Charles H. Townes (Columbia University, New York, N. Y.)

"Gas Analysis by the Mass Spectrometer," by Alfred O. C. Nier (University of Minnesota, Minneapolis, Minn.)

"Radioactive Tracer Techniques and Measurements," by L. F. Curtiss (National Bureau of Standards, Washington, D. C.)

THURSDAY, SEPT. 16—2:30 P. M.

A.I.E.E. Session on Electronic Instruments. Room 200. Chairman, R. Feldt (Allen B. DuMont Laboratories, Inc., Passaic, N. J.)

"Fail-Safe Operation of Electronic Circuits," by G. D. Hanchett (R.C.A. Mfg. Co., Camden, N. J.)

"Cathode Ray Oscillograph Developments for Laboratory and Production Use," by C. Berkley (Allen B. DuMont Labs., Inc., Passaic, N. J.)

"Oil Film Thickness Indicator for Journal Bearings," by Mr. M. L. Greenough (National Bureau of Standards, Washington, D. C.)

THURSDAY SEPT. 16—8:00 P. M.

I.S.A. Session on Instruments in Crime Detection. Ballroom.

"Science in Crime Detection," by L. V. Boardman (Special Agent in Charge, Philadelphia office, Federal Bureau of Investigation, Philadelphia, Pa.)

FRIDAY, SEPT. 17—10:00 A. M.

I.S.A. General Instrument Session Room 200. Technical Chairman, E. D. Wilson (Worcester Polytechnic Institute, Worcester, Mass.)

"Flow Measurement of Gases and Liquids through Primary Elements in Pipe Sizes of less than Two Inches," by Henry W. Stoll (Taylor Instrument Cos., Rochester, N. Y.) Paper No. 48-5-1.

"Instrumenteering — Trinket or Tool," by J. Johnston, Jr. (E. I. Dupont de Nemours Corp., Wilmington, Del.) Paper No. 48-5-2.

"The Development of Instrument Curricula," by M. B. Hall, (Foxboro Co., Foxboro, Mass.) Paper No. 48-5-3.

FRIDAY, SEPT. 17—2:30 P. M.

A.I.E.E. Session on Electronic Instruments. Room 200. Chairman, W. R. Clark (Leeds & Northrup Co., Philadelphia, Pa.)

"Resume of A.I.E.E. Conference on Electron Tubes for Instrumentation and Industrial Use Held in Philadelphia March 29 and 30," by W. R. Clark (Chairman A.I.E.E. Joint Subcommittee on Electronic Instruments.)

"A Study of Slide Wire Contact Resistances," by W. E. Belcher, Jr. (Brown Instrument Co., Philadelphia, Pa.

"Development of Self Balancing Recorders," by A. J. Williams, Jr. (Leeds & Northrup Co., Philadelphia, Pa.)

"Salinity-Temperature-Depth Recorder," by A. W. Jacobson (Bristol Co., Waterbury, Conn.)

Polarographic Analysis

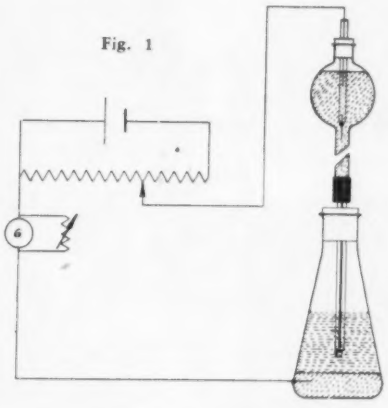
Principles—Techniques—Applications

By LYNN D. WILSON, Corn Products Refining Company, Argo, Illinois

THE polarographic method of analysis is essentially a special type of electrolysis using a dropping mercury electrode. If, in the course of the electrolysis, increasing voltages are plotted against resultant currents, there are obtained current-voltage curves from which it is possible to determine both the nature and concentration of an electrolyzable substance. This is the basis of the polaragraphic method which was devised about 1922 by Professor Jaroslav Heyrovsky of the Charles University of Prague. The field has expanded by leaps and bounds since that date but in the space available for this discussion, it will be impossible to go into any extended treatment of the subject. In fact, only the barest of introductions can be made, but it is hoped that this will be sufficient to indicate the versatility of the method.

The polarographic method of analysis is a unique form of electro-analysis involving the evaluation of current-voltage curves obtained on the electrolysis of electro-oxidizable or reducible substances in a cell so constructed that one electrode, usually the anode, consists of a quiet pool of mercury or a standard reference half-cell such as the calomel electrode, while the other electrode consists of fine, slow drops of mercury exuding from a capillary orifice. The curves resulting from this type of electrolysis allow the simultaneous qualitative and quantitative determination of substances so electrolyzed, and under proper conditions more than one substance may be so identified and measured. The optimum concentration range for the method is from 10^{-5} to 10^{-2} molar, but with appropriate technique involving the use of volumes as small as 0.1 ml, less than microgram quantities may be determined.

Fig. 1



The essentials of polarographic instrumentation are relatively simple and, as shown in Fig. 1, consist of a voltage divider arrangement for applying a gradually increasing potential to the electrolysis cell, which in this case consists of a pool of mercury as the anode while the cathode is made up of a reservoir of mercury, connected to a capillary orifice. The diameter of the orifice is customarily about 0.05 mm; the drop of the mercury is about 2 to 4 seconds per drop and the maximum diameter of the drops is about 0.5 mm at the breaking point. In series with the cell and voltage divider is a galvanometer usually of a sensitivity of about 3×10^{-9} amperes per mm for measuring the current flowing during the electrolysis. Applied EMF's may be measured either with a potentiometer or by observation of the position of the wiper arm of a precision voltage divider. An alternative arrangement for measurement of current involves replacing the galvanometer with a precision resistor and observing the IR drop across the resistor. Both of these arrangements are available in commercial instrumentation either for hand operation and recording, or as a completely automatically operating and recording unit.

Fig. 2 shows the Heyrovsky-Njedly Micro-Polarograph manufactured in Prague. This apparatus automatically applies an increasing potential from 0 to 4 volts by means of a governor-controlled clock-work mechanism driving a helical precision resistor mounted on a fiber disc. Current is measured by a sensitive galvanometer equipped with an Ayrton shunt. Galvanometer deflections are photographically recorded on a cylindrical drum carrying ordinary bromide paper and mounted axially with the slide wire disc. Fig. 3 shows the first American model of

*Presented at the Second Annual Conference of the Instrument Society of America.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

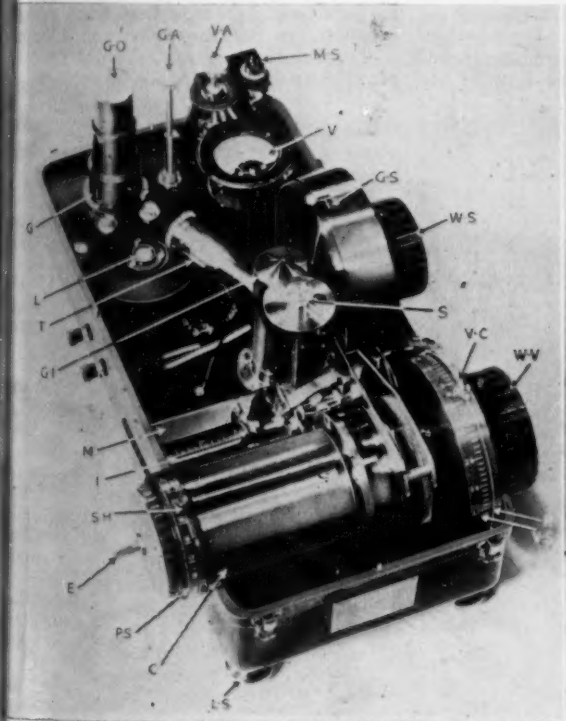


Fig. 2. Heyrovsky-Njedly Micro-Polarograph. (Manufactured in Prague.)

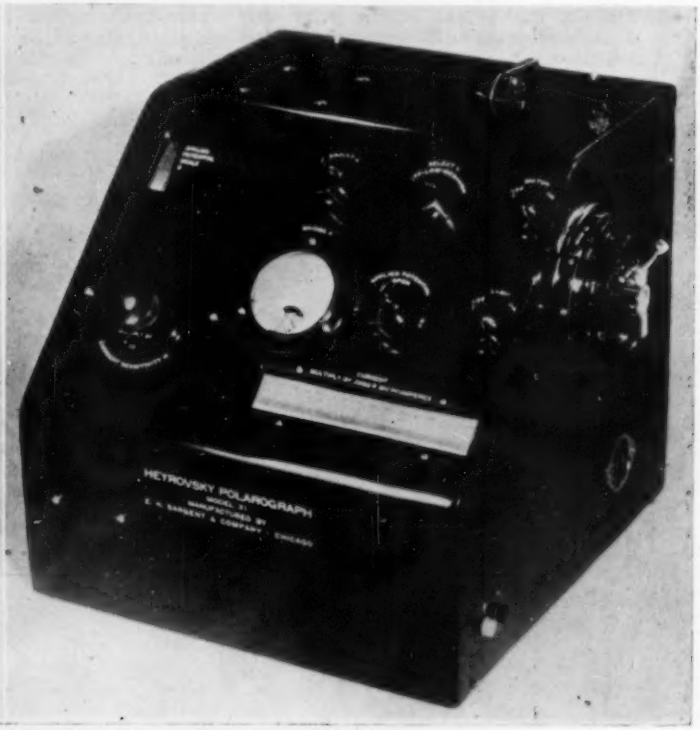


Fig. 3. First American model of Heyrovsky Polarograph. (E. H. Sargent and Co.)

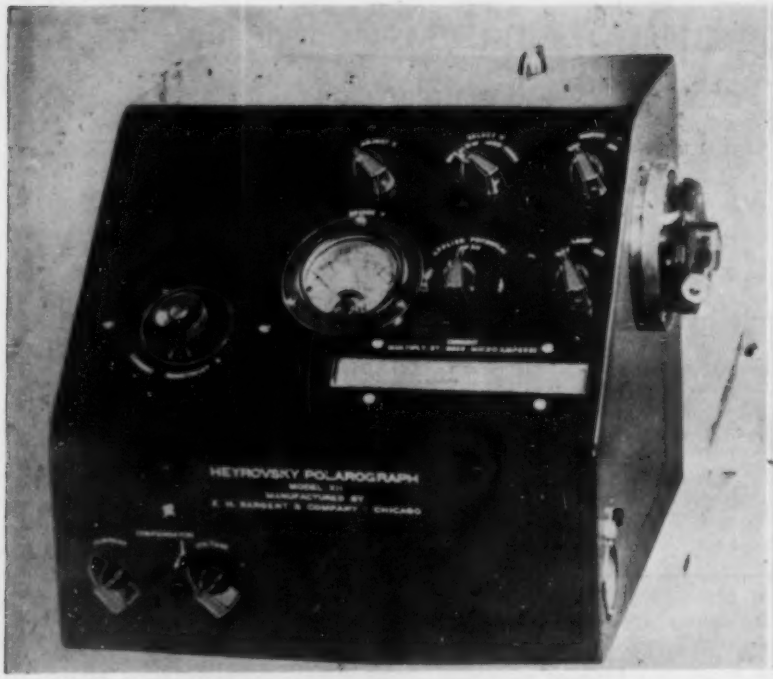


Fig. 4. Model XII Heyrovsky Polarograph. (E. H. Sargent and Co.)

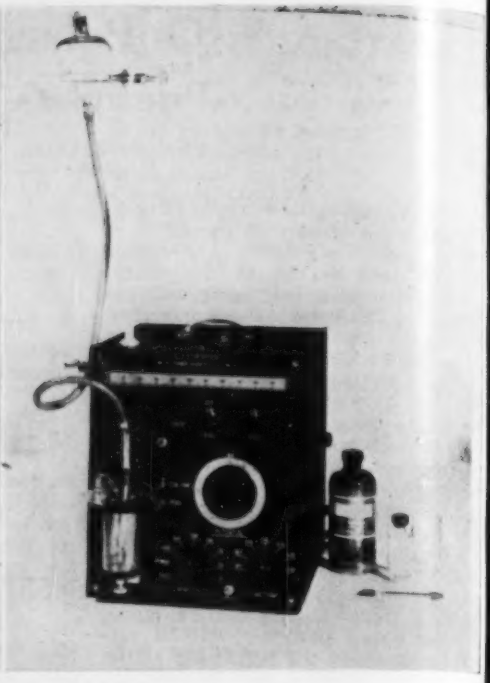


Fig. 5. Electropode. (Fisher Scientific Co.)

the Heyrovsky Polarograph manufactured by E. H. Sargent and Co. It is essentially the same as the European model but is constructed in accordance with American principles of manufacture and design. An improved model is shown in Fig. 4 wherein the apparatus is equipped with a compensating device for blocking out undesired currents (vide infra). Apparatus for applying potentials by hand and visually noting galvanometer deflections is shown in Fig. 5. This apparatus is known as the Electropode and is manufactured by Fisher Scientific Co. The Electro-chemograph, Fig. 6, manufactured by Leeds and Northrup Co. makes use of the principle of measuring the IR drop across a precision resistor and records the equivalent current on a Micromax recorder. Fig. 7 shows the latest American model of the Heyrovsky instrument. This apparatus also measures currents through a resistor and records them on a Brown recorder. In addition, it is equipped with compensating devices and a condenser damping arrangement for reducing the magnitude of galvanometer oscillations resulting from the growing drops of mercury exuding from the cathode.

A typical polarogram resulting from the polarographic electrolysis of an air-free solution of 0.001 M lead nitrate in 0.1 M potassium nitrate is shown in Fig 8. Increasingly negative potentials are plotted on the abscissa while resultant currents are plotted on the ordinate. It will be observed that at first only a very small residual current flows through the cell with increasing applied voltage until the decomposition potential is reached at about -0.40 volts (vs. the saturated calomel electrode) at which time continuous electrolysis begins. During the electrolysis, lead is deposited in the cathodic mercury drops to form a dilute amalgam while anodic mercury goes into solution to form mercurous nitrate. The current does not increase continuously with increasing applied potential but instead levels off and becomes constant and independent of further increase in applied voltage. This constant or limiting current is directly proportional to the concentration of material being reduced at the cathode and it is this fact that makes quantitative polarography possible.

The limiting current results from a practically complete state of concentra-

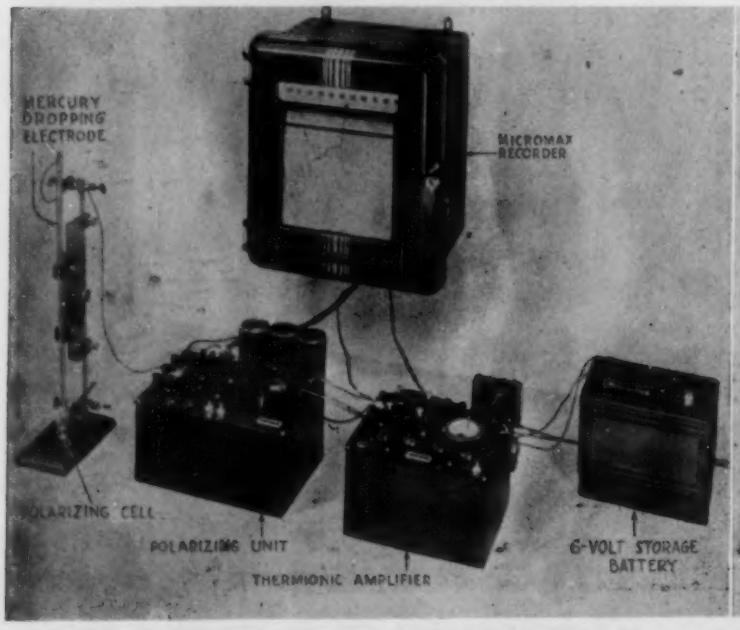


Fig. 6. Electro-chemograph. (Leeds & Northrup Co.)

Fig. 7. Model XX Polarograph. (E. H. Sargent and Co.)

tion polarization at the cathode. In the course of the electrolysis, the concentration of depositing material is depleted at the surface of the cathode and is replaced only by diffusion from the bulk of the solution. The rate of diffusion is directly proportional to the difference between concentrations at the cathode surface and in the bulk of the solution. As electrolysis proceeds, the concentration at the cathode surface becomes so small that the difference between the concentrations at the cathode surface and in the bulk of the solution is practically equal to the concentration in the bulk of the solution. When this point is reached, the rate of diffusion becomes constant; hence the amount of material discharging at the cathode becomes constant and the current also becomes constant and proportional to the concentration of reducible substance in the bulk of the solution. Since this current is controlled by the rate of diffusion it has become known as the diffusion current.

Among the conditions necessary to the attainment of a diffusion current which is strictly proportional to the concentration of reducible substance are (1) a physical arrangement resulting in an extreme state of concentration polarization—namely, one elec-

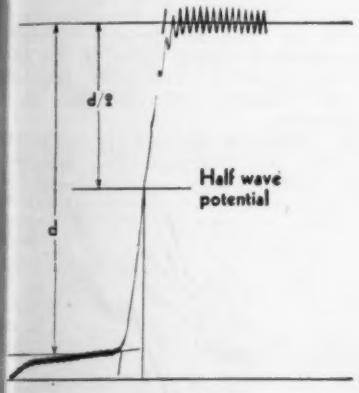


Fig. 8

trode very small and the concentration of reducible material not too large, and (2) elimination of any electrical force which might supply ions to the cathode by electrical migration. This latter condition is met by having the electrolysis occur in the presence of a large excess (50 to 100 times) of an indifferent salt, which may be defined as a substance which is reduced at potentials much more negative than the material in question. Customarily, these indifferent electrolytes are the salts of the alkali metals or tetra-substituted ammonium salts. Fig. 8 also shows the geometrical intercept method for measuring the diffusion current as the difference between the residual current and the total wave height. This current can be expressed as mm of wave height, or, knowing the galvanometer sensitivity, in terms of microamperes. In polarographic work this current seldom exceeds 50 microamperes. The value of the voltage at half the diffusion current is the decomposition-al potential characterizing the ion in question and is known as the half-wave potential. This value is chosen since it has been shown to be independent of concentration, particularly capillary used and drop time. Fig. 9 shows how a series of ions may be identified by means of the half-wave potentials at which electro-deposition occurs.

The values of the diffusion current for a given set of conditions can be calculated by means of the Ilkovic equation, Fig. 10, where "n" is the number of electrons involved in the reaction, "F" is the Faraday, "C" is the concentration, "D" is the diffusion coefficient of the ion, "M" is the mass of mercury, and "T" is the drop time. This equation is of value in studying mechanisms of reaction; for instance, the number of electrons involved in a

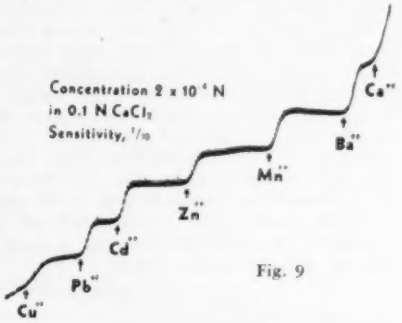


Fig. 9

Fig. 12 (Below)

$$i = 0.63 \cdot nF \cdot C \cdot D^{1/2} \cdot m^{2/3} \cdot t^{1/6}$$

Fig. 10

and the respective wave heights, the unknown concentration can then be calculated.

It was mentioned in connection with the typical polarogram of Fig. 6 that the electrolysis took place in an air-free solution. The reason for this requirement is that dissolved oxygen is reducible at the dropping mercury

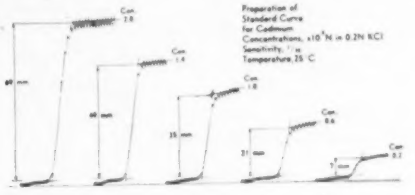


Fig. 11

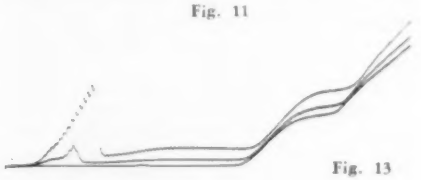
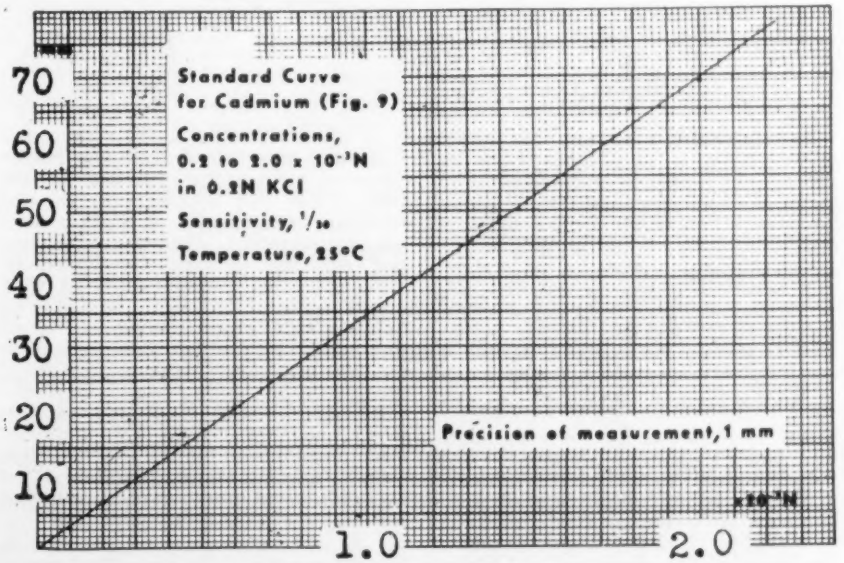


Fig. 13



reaction may be determined by measurement of diffusion currents under fixed conditions. Fig. 11 shows a series of calibration curves for the cadmium ion in varying concentrations, while Fig. 12 shows this calibration information plotted as mm of wave height against concentration. Calibration curves of this form are frequently used in routine analysis but complications develop if it becomes necessary to change experimental conditions such as replacement of a capillary. If this is necessary, a new curve must be made. Uniformity of temperature must be observed, since the temperature coefficient of the diffusion current is approximately 1% per degree C. Where a wide variety of analyses is in progress, it is much better to measure concentrations by the method of internal calibration which involves the addition of a known volume of known concentration of the ion in question to a known volume of the unknown, and re-running the polarogram. From the known constants of concentration

electrode as shown in Fig. 13. The upper curve results from the electrolysis of 0.001 M potassium chloride and is strictly characteristic of oxygen. Obviously, such a wave form would interfere with the wave forms corresponding to metals having deposition potentials within that range and consequently dissolved oxygen must be removed. This is easily done by merely bubbling hydrogen or nitrogen through the solution before electrolysis for a period of from 2 to 30 minutes depending on the sensitivity required for the measurement. The middle wave of Fig. 13 shows the effect of a 30 second bubbling with hydrogen while the lower wave shows oxygen completely removed after a further 2 minute bubbling. The oxygen wave is of additional interest in that it displays a typical maximum, which in this case is completely characteristic and quantitatively proportional to the oxygen concentration. Maxima also occur in polarographic reductions of the metals but in these cases they differ from

the oxygen maximum in that they may or may not occur depending on solution conditions, and they are not quantitatively related to metal ion concentrations. The occurrence of maxima tends to distort quantitative relations so that, in any determination of concentration, every effort must be made to forestall their appearance. Fortunately, maxima are relatively easy to suppress merely by the addition of small quantities of capillary active substances like gelatin or some of the

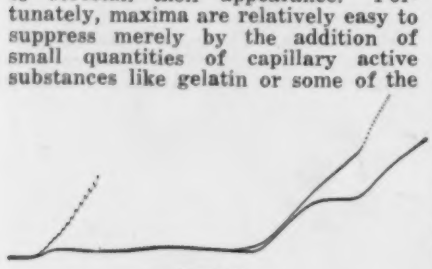


Fig. 14

organic dyes like methyl red, and fuchsin, methylene blue, etc. Fig. 14 shows the effect on the oxygen maximum of the addition of a few drops of a 1% gelatin solution. Note that the maximum is completely suppressed and a two-wave polarogram has become defined. The first wave represents the reduction of oxygen to hydrogen peroxide, and the second wave corresponds to the reduction of hydrogen peroxide to water. The peroxide wave is also characteristic of organic peroxides and can be used for qualitative and quantitative measurements.

As an example of applied polarography, the analysis of a zinc-base die-casting alloy may be considered. This particular analysis serves to illustrate the several conditions which must be met before the feasibility of a polarographic approach may be determined. The sample in question was one of a series of experimental melts on which analytical information on the copper, lead and cadmium content was desired. Copper was present to the extent of 0.2%, while the lead and cadmium were about 0.004% each. In addition, traces of iron and tin were also present, but quantitative data on these metals were not desired. Examination of a table of half-wave potentials for these metals indicates that cupric copper and ferric iron would deposit at the same voltage, about +0.02 volts, so that one single wave form for the combined metals would result. However, copper was present in such great excess over the iron, that the contribution of the iron to the total wave height was negligible and could thus be disregarded. Lead has a half-wave potential of about -0.40 volts and cadmium of about -0.60 volts, so there existed sufficient voltage separation between these metals for the formation of separate, well-defined waves. However, tin was also present and since its half-wave potential is close to that of lead the two would tend to form one wave. Again, in this case since it was present in only trace amounts its contribution to the lead wave was negligible. Even if it had been present in relatively large quantities the problem would not have been insoluble, since several chemical means of separation are available. Thus, for instance, if the sample were put into solution in nitric acid, the tin would form insoluble metastannic acid and could be mechanically removed after a suitable washing to prevent absorption of other soluble ions.

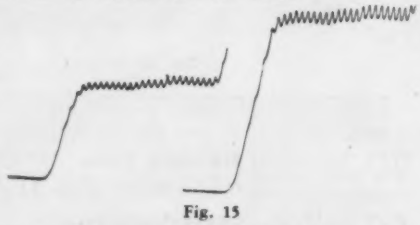


Fig. 15

Having ascertained that the polarographic method was feasible in this case, it was only necessary to prepare solutions for analysis. A 5 gram sample was dissolved in concentrated nitric acid, the solution was boiled to expel oxides of nitrogen, diluted with several volumes of water, and re-boiled to coagulate the metastannic acid which was centrifuged out. The precipitate was washed several times with small quantities of boiling water and the combined filtrates made up to 100 ml in a volumetric flask. A 5 ml aliquot was transferred to a polarographic cell, 0.1 ml of 0.1% acid fuchsin added to suppress any copper maximum and a polarogram taken as shown in Fig. 15. The first large wave was due to the copper while the two small waves apparent on the copper crest are due to lead and cadmium, respectively. The sharp rise at the end of the polarogram is due to the zinc which in this case served as the indifferent electrolyte. The copper content was measured by the method of internal calibration by the addition of 0.5 ml of a copper nitrate solution about 12 times as strong as the original. The second curve shows the increase in wave height due to the addition of the calibrating amount of copper.

It would seem that all that is necessary to determine the lead and cadmium would be to extend the sensitivity of the galvanometer to increase the wave height of the two metals. However, in this case, the diffusion wave of the copper would also be increased and since it is present in such a great excess over the lead and cadmium, all that would happen is that the waves for the lead and cadmium would not appear on the polarogram at all. Several solutions for this problem are available. Thus, a current equal in magnitude but opposite in polarity to the copper current might be fed into the polarograph to block out the copper current. This is the principle of the compensating device mentioned earlier in connection with the more modern polarographs. Chemical means may also be used such as precipitating out the copper or tieing it up in complexes which do not allow interfering deposition. In this problem the copper was reduced to the cuprous state from which it apparently does not deposit in acid solution.

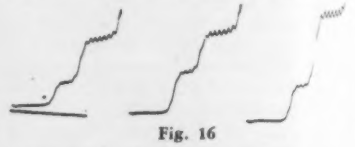


Fig. 16

After measuring the copper content, several small crystals of hydroxylamine hydrochloride were added to the sample in the electrolysis cell and stirred into solution by the bubbling action of the hydrogen used for oxygen removal. Galvanometer sensitivity was extended and another polarogram taken as shown in Fig. 16 where the first wave is due to the lead and the second to the cadmium. Internal calibration completed the measurement as shown in the next two curves. The results of this analysis were very gratifying in that spectroscopic results were checked within 0.1% of the percentage present. The time required for the complete analysis was about 30 minutes.

As another example of applied polarography, the analysis of a lead-zinc paint pigment may be considered. A

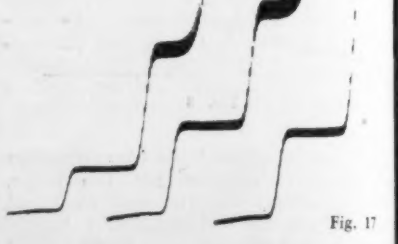


Fig. 17

paint sample was centrifuged to precipitate the pigment which was then extracted with a suitable oil solvent to obtain an oil-free sample. A 0.25 gram sample of the clean, dry pigment was dissolved in concentrated nitric acid and made up to 100 ml with 0.1 M potassium chloride as indifferent electrolyte. Fig. 17 shows the polarogram of the original sample at the left. As before, internal calibration for lead resulted in the increased lead wave in the middle curve while the zinc increase is shown in the curve at the right. The results of the analysis showed the lead content to be 48% and the zinc 52% which establishes the pigment as a "leaded-zinc" pigment.

Innumerable other examples could be cited in the fields of white metal analysis, steel analysis, electro-plating solution studies, etc., to say nothing of the field of organic chemistry where almost any group normally regarded as reducible by hydrogen will lend itself to polarographic determination.

The Author

Lynn D. Wilson is head of the Instrument Development Section, Control Engineering Group, Corn Products Refining Company, Argo, Illinois, and has held this position since 1946. He received his BS in Chemistry in 1930 and MS in 1932 from Marquette University.

After work at the University of Wisconsin in 1932-34 he received his PH.D. in Chemistry from Marquette in 1938 and a Certificate in Inorganic and Organic Microchemistry from New York University. He was then Chief Chemist, and later Director of Research for E. H. Sargent & Company and came to his present position after serving in the U. S. Navy on communications duty.

Section News

(Continued from page 641)

ecretary, T. S. Cawthorne, and Treasrer, Wallace Moline.

The June meeting will be a social eeting to allow members to become acuainted with each other and to introuce the ladies to some of the workings f the ISA. A technical movie, "The Uses f High Speed Photography" and the olor film "Pueblo Boy" will be presented, fficers will be installed, and refreshents will be served. The June meeting ill conclude a season that has been alled by many members of the most interesting yet presented by the Detroit ection. —WILLIAM E. WILSON, *Corr.*

KANSAS CITY

On May 25th, Kansas City Section met t the Crossroads." Clayton H. Barnard. pplication Engineer, Bailey Meter Comany, presented an illustrated talk on Electronic Instruments and Controls for he Process Industries." He showed illustrations of the various types of indiators, controllers and recorders for temerature, flow, pressure, percent oxygen nd percent combustibles. His explanaion of the circuit used for temperature nd pressure compensated flow meters as of unusual interest to the members. —W. A. REICHOW, *Corr.*

LOUISVILLE

On May 25th, the Louisville Section eard a very interesting talk by Mr. C. B. Moore of Moore Products Company on The Solution of Instrumentation Probems by the Pneumatic Null Balance Method." After a brief discussion of the asic fundamentals of force balance and he pneumatic force balance system. Mr. Moore explained his pneumatic pressure egulator. Mr. Moore is that rather rare ombination of a technician and an interesting speaker. The meeting was held the Joseph E. Seagram Auditorium ith the president, J. J. Monahon, preiding.

The last meeting of the spring series as held on June 22, 1948, with Vicepresident Estus Ballard presiding. Mr. ictor P. Head, Fluid Research Engineer, Fischer-Porter Company, spoke on Tough Fluids and Their Handling." He ressed dimensional analysis and other actors affecting fluid flow.

A social half hour with refreshments ollowed the meeting.

—PAUL B. SMITH, *Sec'y*

OAK RIDGE

On May 26th, the Oak Ridge Section eld a special meeting in order that we ight avail ourselves of the privilege f hearing Mr. E. E. George, Metallurgial Department of the General Electric ompany. His topic was "Thermistors." His talk covered the origination of the nit, methods of manufacture, and direct pplications. After giving us the low down on the gadget, we were shown ctual usage by means of test panels n various forms.

Our regular meeting, held June 2nd, as highlighted by a local speaker. Dr. W. H. Ray of the Oak Ridge National aboratories. His topic being "Healthhysics Instrumentation." The talk dealt eavily on the point, "what is required f the instruments rather than what the nstruments can do." In a very able manner we were given the requirements and he need for their being rather strict. nstrument men in this field certainly reeived a definite challenge to meet the pecifications. —J. O. ALEXANDER, *Sec'y*

PITTSBURGH

The last spring meeting of the Pittsburgh Section, ISA, was held on May th in the Lecture Hall at Carnegie luseum. It was preceded by a dinner n the Museum Cafeteria.

The meeting was opened at 8 P.M. with members present. The minutes were ead by Secretary Susany, and President W. Prince presented the financial reort, in the absence of Treasurer Clarke ry. Dick Rimbach gave a short report n the arrangements for the Philadelphia eeting and exhibit. A preliminary reort on next season's program was preented by Henry Fulton.

President Prince then introduced the ewly elected officers and executive oard (announced last month) and turned he meeting over to the new President, R. M. Kendig of Westinghouse Air Brake. Mr. Prince was elected Chairman of a newly formed Section Historical Committee.

Mr. Kendig then introduced the speaker, Dr. Markson of the Hagan Corp., who spoke on "Pneumatic Force Balance Instruments." Dr. Markson described his company's Thrustorq transmitter for force measurement, as in dynamometers and weigh bins. He discussed the properties of diaphragms both slack and molded, and the accuracy attainable with the instrument. After a lengthy discussion period, meeting adjourned at 10:40 P.M.

—M. M. FROMM, *Corr.*

RICHLAND

On a return engagement, Mr. S. B. Biddle of Leeds and Northrup Co., San Francisco branch, lectured on the "Theory and Practice of pH Measurement" at the regular meeting of the Richland Section, May 12. Mr. Biddle, who ordinarily likes to be practical, gave forth with a concentrated and well prepared lecture leaning toward the theory of pH measurement. First, he defined pH and discussed the chemical and mathematical derivation of the pH scale. Then he described the development of pH measuring devices and problems overcome by pioneers in the field. Dole is given credit for developing the glass electrode, much in use today, in the early 1920's at the University of Chicago. With new and secret varieties of glass, today, much more sensitive electrodes are made. In conclusion, Mr. Biddle pointed out some of the problems of automatic control of pH and gave some useful hints on the maintenance of pH equipment. Needless to say we found the lecture both interesting and educational.

Added features of the meeting included two movies "Adventures in Science" and refreshments of coffee, cake and ice cream.

The program committee has tentatively scheduled for the June meeting a talk on Automatic Controls by J. G. Ziegler of the Taylor Instrument Co.

—JOHN FLICKINGER, *Corr.*

ROCHESTER

The fifth and final meeting of the Rochester Section for the spring season was held May 20th at 8:00 P.M. in the Physics Building on River Campus of the University of Rochester, Rochester, New York. Mr. Harvey Klumb of Rochester Gas and Electric Co., was the speaker of the evening. A very interesting discussion of the "Electrical Power Distribution in Rochester" was given by Mr. Klumb. He has been employed by Rochester Gas and Electric for several years and is at present Superintendent of Electrical Distribution for the company.

The general electrical distribution network for the city was shown with emphasis on such places as voltage change locations, substation and branching points. A map of the city was used to illustrate this system. A brief history of the system was given to point out the many factors which must be taken into consideration in constantly increasing the distribution capacity. It was pointed out that the normal system would double in capacity about every 12 years. Slides and photographs illustrated various pieces of equipment such as cables, poles, supports, sub-stations, conduit, switches, etc. One interesting point in this phase of the talk was the fact that different locations in the city require different design and architecture. As would be expected, equipment requirements continually change and consequently a constant alteration program is necessary. The talk was continued with a detailed explanation, supplemented with slides, of the operation of laying a new underground cable down one of Rochester's main thoroughfares. All operations were described beginning with digging of trench and continuing with the laying and cementing of conduit, pulling of cable, splicing of cable, installing junctions, and testing and putting into operation. A brief portion of the talk was given to the explanation of the street lighting system and some of the maintenance problems involved.

Mr. Richard Rimbach was present and discussed several important matters with the Section. He answered questions concerning the Society which had been raised by the membership. We enjoyed Mr. Rimbach's visit and welcome at any time the visitation of national and sectional officers and members.

A short business session concluded the meeting. Mr. Al Harmon was appointed National Director. The next meeting of the Section will be held September 28, 1948, with Mr. Harold Crouch of Eastman Kodak Company as guest speaker.

—CHARLES W. COVEY, *Corr.*

SOUTH BEND

On May 13th an educational program was presented by the Brown Instrument Company—Division of Minneapolis-Honeywell Regulator Company, before a group of 29 members. Mr. H. M. Schmitt, Manager of the Chemical Industries Division, presented a very interesting talk on the most recent developments in Measurement and Control by the Brown Instrument Company. He featured the "Low Range Radiamatic" pyrometer capable of measuring temperatures from plus 1600 degrees F without a direct contact with the medium being measured. Slides accompanied this discussion and Mr. Schmitt also had demonstrating equipment which included the "Low Range Radiamatic" instrument.

Chairman for the evening was Mr. George E. Gilliam, president of the South Bend Section of ISA. With the membership drive on, each member was urged to bring in new candidates and each member bringing in three new members will be awarded an ISA pin.

The June 3rd meeting was conducted by Leeds & Northrup Company, Chicago, Illinois, before a group of 26 members. Mr. J. B. Higley, Head Field Engineer of Leeds & Northrup Company, discussed "Some Development in Temperature

Who's Who in the I. S. A.

W. H. SISSON

Director, Central Indiana Section

"Bill" Sisson, Central Indiana Section Delegate, has been very closely associated with Industrial Instruments for the past 26 years and is widely known throughout the midwest section of the United States.

He attended the University of Illinois and supplemented his education with courses at the University of Kansas and the University of Kansas City. Bill was associated with The Texas Co. for six years and then transferred his activities to The Brown Instrument Co. in their Chicago District. He was later transferred to Peoria, Ill., then Kansas City, Mo. and is now located in Indianapolis, Ind. as Industrial Manager for that territory.

During the four years spent in Kansas City, he was instrumental in organizing The Kansas City Industrial Instrument Society long before the advent of I.S.A. He also aided in the organization of the Central Indiana, South Bend and Louisville Sections of I.S.A. Bill has served as President, Chairman of the Board of Directors and is now Delegate of his local I.S.A. Section.

Aside from his regular duties, Bill has developed a couple of unique ideas on instrumentation which have resulted in patents. He enjoys fishing and during vacations can be found at one of his favorite spots in Wisconsin, Michigan or in the Ozarks. His hobby was photography for several years but now has turned to his first love, "Ham Radio." A new Kilowatt Transmitter, C. W. and phone, is in the process of construction and will be "On the air" late this year.

Recording and Control Equipment." This talk was primarily limited to the new L&N Speedomax Signalling Controller. A demonstration instrument of each type was on display during the meeting. Mr. J. H. Brewer of Leeds & Northrup accompanied the guest speaker and he also discussed the evaluation of control instrument performance.

—MARIUS WOLFF, *Corr.*

SOUTHERN MICHIGAN

At the May meeting a slate was proposed by the Nominating Committee and presented by Mr. Walter Marburger, the chairman:

President . . . Mr. Ken Mead, *Vice-president* . . . Mr. Leon Simkins, *Secretary* . . . Mr. Homer Kuiper, *Treasurer* . . . Mr. Dale Goodsell, and Mr. Ed Stevens.

After a motion was made to close the nominations, further discussion led to the holding open of the nominations until the June meeting.

Mr. Wade Allen introduced Mr. R. R. Proctor of Pure Oil Research and Development Laboratories, Northfield, Illinois, who spoke on "The Electronic Road Test Panel." The so-called octane number or octane rating of fuels has for years been determined on a CFR engine, running at 600 rpm. for the Research Method, and at 900 rpm. for the Motor Method. Though this procedure is still standard in all laboratories, it does not give a complete picture of the fuels since its rating is determined at only two speeds.

The Borderline Method determines the octane rating over the entire range of speed. Briefly, the fuel rating is determined by plotting a framework of reference fuels and superimposing the unknown fuel on the framework to determine its octane rating at any speed. All fuels are run by using a car in which the distributor, governor, and vacuum advance have been locked out and a manual control installed. The distributor is first set so that ignition occurs at a point somewhere near top dead center. With the car in high gear and running at 8 to 10 mph. on a level road, it is accelerated at wide open throttle and the speed at which the knock fades out is recorded. At least two check runs are made, or more if necessary, until the same fade-out speed is agreed upon by two observers. The spark is then advanced two degrees and the procedure repeated, then two more degrees, and so on, until a complete curve had been plotted for speeds up to 7 miles per hour.

Instrumentation involves the measurement of spark advance and the engine speed. The measurement of spark advance is accomplished by a tricky circuit of thyratrons and meter. The engine speed is determined by use of several tubes and a meter, having a switch for using with four, six, or eight cylinder engines. A necessary component of the instrumentation is a constant voltage supply obtained with the use of tubes along with the vibrator and transformer.

At the June meeting, the Secretary's and Treasurer's reports were accepted as read. A motion was made, seconded, and carried to accept the President, Vice-president, and Secretary as proposed by the nominating committee. The Treasurer was elected by a 9 to 3 vote. The officers for the next year are:

President . . . Ken Mead
Vice-president . . . Leon Simkins
Secretary . . . Homer Kuiper
Treasurer . . . Dale Goodsell

The notice sent out by Richard Rimbach, the National Secretary, asking for the names of the officials of the organizations which employ ISA members was read. A proposal was presented to the membership suggesting that there be a "tie-in" with other sections, such as Wayne, Detroit, etc., which would mean changing the meeting day to the third Wednesday of the month. A vote on this change was deferred until September. Wade Allen, the program chairman, introduced Mr. Earl C. Rieger of International Harvester Company, Chicago, Ill., who spoke on "An Instrument Maintenance Program."

Mr. Rieger divided his talk into five sections as follows: (A) Fix it before it happens. (B) Take down the fence. (C) Routine and special instruments. (D) Examples of special problems. (E) Idea exchange.

Under the first section it was pointed out that a breakdown usually occurs at a time when it can be least tolerated. The logical remedy is to have routine maintenance and "fix it before it happens." "Take down the fence" applies to the ill will which is created between the instrument maintenance department and those who have to rely on the data obtained from the instruments. It is imperative that all concerned know the limitations of the instruments and do not try to stretch the accuracy. Of course, along with this goes the universal failing of trying to "pass the buck." In the case of routine and special instruments an operator with a short period of instruction is competent to handle the situation, but when trouble arises which is outside the usual gamut of ills, a man with a thorough knowledge of the instrument is needed. Information and instruction sheets are extremely valuable. An important quality of the instrument supervisor is to be able to detect when it is more expedient to do the work or to send it out, and also whether or not an instrument is beyond the repair stage. This decision is dependent upon quite a number of factors. The examples of special problems were too numerous to list here, but they covered a good portion of the physical sciences. There has been an overdose of ballyhoo about electronics, just as in the case of atomic power. Electronics is not the answer to all problems, but like everything else, it has its place.

The fifth section of Mr. Rieger's talk typifies his activities in the ISA. He is a firm believer in the exchange of ideas by those concerned with instrumentation. The medium by which this exchange takes place is through just such an organization as the ISA, and other technical societies. Another type of exchange of ideas is through cooperation within industry, while a third takes place through the activities of colleges and universities.

That there is interest in the technical societies is attested by the fact that there are now about forty sections of the ISA after having been established about two years ago. To accomplish the aim of idea exchange, members should attend meetings regularly and participate by asking questions from the floor.

Mr. Rieger had a reel of film taken on various subjects with the high speed camera, showing the corn planter mechanism, valve spring bounce, fuel injection spray pattern, and a color record of the explosion inside of a cylinder. The N. A. C. A. has a camera which takes about 100,000 frames per second, and there is talk of a camera which will go to 2,000,000 frames per second. An interesting discussion period followed Mr. Rieger's talk. One unsolicited comment was, "It sure made sense."

—R. J. SCHOFIELD, *Sec'y*

SOUTH TEXAS

The South Texas Section visited the Instrument Repair shops of the Naval Air Station, for its May meeting. It was a case of one half getting a chance to see how the other half lives or makes a living. About half our membership are aircraft instrument men; and the other half are industrial instrument men in the refineries and chemical plants in this area. As usual the most interest centered around the famed Sperry Automatic Pilots and the Pioneer flux gate compasses. Some were amazed at the variety of work done in the shop, and one commented that the shop would make an ideal physics laboratory for teaching purposes.

The June meeting will be addressed by Dr. Armstrong Price on "The History of Sand and Clay Dunes in South Texas."

In July we will have a talk and some illustrative movies on meteorology and the recording instruments used. July is also the month for our annual barbecue at Falfurrias given by Homer Givens and the boys from the LaGloria plant there.

—L. NEEDHAM, *Corr.*

WAYNE COUNTY

The regular meeting was held May 1[illegible] in the St. John's Evangelical Church Hall. The speaker was Mr. T. S. Cawthorne, Detroit representative of the Weston Electrical Instrument Corp. The discussion on panel board and test instruments with numerous blackboard sketches, cleared up many points on methods and accuracy of electrical measurements. The effect of temperature and means of compensation and the action of jewel bearings were very interesting.

At a special meeting on May 5, Mr. Malcolm Hall, Supervisor of Training at the Foxboro Co., spoke on instruction and training of instrument men, mentioning progress in setting up instruction courses in several colleges. He also gave a talk with slides, on a "Differential Pressure Transmitter for Pneumatic or Electric Remote Transmission."

—JOHN MACPHERSON, *Corr.*

I. S. A. EMPLOYMENT SECTION

Forward your letter to INSTRUMENT SOCIETY OF AMERICA, 1117 Wolfendale St., Pittsburgh 12, Pa.

INSTRUMENT ENGINEERS for chemical plant installation and maintenance work by manufacturer of chlorine and caustic. Power plant instrumentation experience desirable. Location Louisiana. Box 145.

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INSTRUMENT SALES ENGINEER for unusual sales opportunity in Boston and vicinity with Fisher Governor Co. sales representatives for technical graduate with instrument application and maintenance experience in chemical or petroleum plants. Reply by letter giving age, education and experience. Salary based on experience and qualifications. Box 146.

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INSTRUMENT ENGINEER opening for qualified man with Titanium Div. of National Lead Co., N. J. Write Employment Service, ISA for further information. Box 147.

. . .

ELECTRONIC ENGINEER graduate with degree in electrical or mechanical engineering with experience in electronics. Should have inventive ability with genuine interest in instrumentation. Position would be Supervisor of Electronics of Mechanical Dept. of large pharmaceutical and biological products manufacturer. Location Detroit, Mich. Box 148.

ISA EMPLOYMENT REGISTER

WHEN: Third Annual Conference and Exhibit of the Instrument Society of America, September 13 through 17, 1948.

WHERE: Convention Hall, Philadelphia, Pa.

Seeking a Position in Instrumentation? Registration forms and further instructions may be obtained from the Society Office. Pre-registration by applicants is advisable, as records will be made available to prospective employers before the week of the Conference and Exhibit.

Do You Need An Instrument Man? Companies or institutions seeking instrument men are requested to file notice of open positions prior to the week of the Conference and Exhibit so that qualified applicants may be selected for interview.

Interviews Arranged. Representatives of employers and applicants attending the Conference are urged to report to the office of the EMPLOYMENT REGISTER immediately upon arrival so that interviews may be arranged.

The Instrument Society of America, 1117 Wolfendale St., Pittsburgh 12, Pa.